ACQUISITION RESEARCH PROGRAM SPONSORED REPORT SERIES

Analysis and Recommendation for a Fifteen Percent Cut in Space and Naval Warfare Command for Management Support Services

30 June 2013

LCDR Kurt Celis, USN

LCDR Warren Sherman, USN, and

LCDR Matthew Shiels, USN

Advisors: Simona Tick, Lecturer, and
Steven Landry, Visiting Professor

Graduate School of Business & Public Policy

Naval Postgraduate School

Report Documentation Page		*Form Approved* *OMB No. 0704-0188*

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE **30 JUN 2013**		2. REPORT TYPE		3. DATES COVERED **00-00-2013 to 00-00-2013**
4. TITLE AND SUBTITLE **Analysis and Recommendation for a Fifteen Percent Cut in Space and Naval Warfare Command for Management Support Services**				5a. CONTRACT NUMBER
				5b. GRANT NUMBER
				5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)				5d. PROJECT NUMBER
				5e. TASK NUMBER
				5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Postgraduate School,Graduate School of Business and Public Policy,Monterey,CA,93943**				8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**

13. SUPPLEMENTARY NOTES

14. ABSTRACT **In this MBA project, we develop a linear programming model to use as a capital budgeting decision support tool for the Space and Naval Warfare Systems Command (SPAWAR). The Office of Management and Budget (OMB) is requiring a 15% reduction in SPAWAR?s spending on management support services in the fiscal year (FY) 2014 budget. This thesis develops an operational linear optimization decision model meant to provide analysis and recommendations to support the decision-making by SPAWAR on achieving the required spending reduction within 10 product service codes (PSCs) with minimal impact to the warfighter. The model is easy to use and can be adjusted to account for changes in the decision environment of SPAWAR. Based on our optimization decision model results and analysis, we provide recommendations to SPAWAR for PSC spending that can be effectively utilized for the FY2014 budget.**

15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT **Same as Report (SAR)**	18. NUMBER OF PAGES **87**	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**			

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

ACQUISITION RESEARCH PROGRAM
GRADUATE SCHOOL OF BUSINESS & PUBLIC POLICY
NAVAL POSTGRADUATE SCHOOL

ANALYSIS AND RECOMMENDATION FOR A FIFTEEN PERCENT CUT IN SPACE AND NAVAL WARFARE COMMAND FOR MANAGEMENT SUPPORT SERVICES

ABSTRACT

In this MBA project, we develop a linear programming model to use as a capital budgeting decision support tool for the Space and Naval Warfare Systems Command (SPAWAR). The Office of Management and Budget (OMB) is requiring a 15% reduction in SPAWAR's spending on management support services in the fiscal year (FY) 2014 budget. This thesis develops an operational linear optimization decision model meant to provide analysis and recommendations to support the decision-making by SPAWAR on achieving the required spending reduction within 10 product service codes (PSCs) with minimal impact to the warfighter. The model is easy to use and can be adjusted to account for changes in the decision environment of SPAWAR. Based on our optimization decision model results and analysis, we provide recommendations to SPAWAR for PSC spending that can be effectively utilized for the FY2014 budget.

THIS PAGE INTENTIONALLY LEFT BLANK

ACKNOWLEDGMENTS

The authors would like to thank Professor Simona Tick and Professor Steve Landry for their direction, vision, and patience in the preparation of this thesis. This product would not have been possible without your help and guidance.

Thanks go to the outstanding faculty and staff of the NPS Graduate School of Business and Public Policy for providing us with the requisite knowledge necessary for such an undertaking. We would also like to thank our fellow students for tolerating our unique personalities.

Additionally, we would like to thank Captain Scott Hoffman and LCDR Shane Derby for answering our questions and enlightening us on product service code management and SPAWAR spending processes.

A final thanks to our wives, Alison Celis, Heather Sherman, and Angela Shiels, for their tolerance and strength during our time at Naval Postgraduate School and throughout our careers. It has been said that behind every great man, there must be a great woman; although we are not great men, we are honored and privileged to have these great women as our wives.

THIS PAGE INTENTIONALLY LEFT BLANK

ABOUT THE AUTHORS

Lieutenant Commander Kurt A. Celis enlisted in the Navy in 1995 as a sonar technician (Surface). He served aboard USS *Curtis Wilbur* (DDG 54) while homeported in San Diego and later in Yokosuka, Japan, after the homeport shift. Following his tour on *Curtis Wilbur* STG2(SW), Celis was assigned to USS *Valley Forge* (CG 50) in San Diego as the UBFCS and Torpedo Work Center supervisor.

While serving as a class advisor and course supervisor at Fleet Anti-Submarine Warfare Training Center in 2001, he was certified as a master training specialist. During this period, he also graduated with honors from the University of Phoenix with a Bachelor of Science degree in business and a major in management.

Upon completion of his degree in 2002, STG1(SW) Celis applied and was accepted to Army Officer Candidate School. In July 2003, he enlisted in the Army under the 09S MOS and attended Army basic training at Fort Knox, KY. He was commissioned as an Armor 2LT in February 2004 and attended Basic Airborne School in Fort Benning, GA. After Basic Airborne School, 2LT Celis transferred to Fort Hood, TX, where he was assigned as a tank platoon leader. In December 2005, 1LT Celis deployed to Taji, Iraq, for a 12-month tour in support of Operation Iraqi Freedom. He was promoted to captain in April 2007 while working as a plans officer for 1st Battalion 66th Armor Regiment of 1st Brigade 4th Infantry Division.

In November 2007, Captain Celis was commissioned a lieutenant in the Navy as a supply corps officer. His first supply officer tour was as the supply officer onboard USS *Vandegrift* (FFG 48) in San Diego, CA. During his tour, *Vandegrift* was awarded the Best in Class award for retail operations in 2009 and the Captain Edward F. Ney Memorial award for 2009. Following *Vandegrift*, LT Celis served in USS *Bonhomme Richard* (LHD 6) as the assistant supply officer, stock control officer, materials division officer, and wardroom officer. He is currently a student at the Naval Postgraduate School and will graduate in June 2013 with a Master of Business Administration in Financial Management.

LT Celis is married to Dr. Alison Celis, a prior Army Major in the Medical Corps. They have one daughter. LT Celis's personal awards include the Bronze Star Medal, Navy Commendation Medal (two awards), Army Commendation Medal (Four Awards), Navy and Marine Corps Achievement Medal (Three Awards), Good Conduct Medal (Two Awards), and various unit and campaign awards.

LCDR Shiels was raised in Northampton, MA. He enlisted in the Navy in February 1995 and attended boot camp at Recruit Training Command in Chicago, IL, and then attended "A" school at Keesler AFB, Biloxi, MS, where he was designated an aerographer's mate. After completing A school in June 1995, LCDR Shiels was assigned to Naval Meteorology and Oceanography Command West/Joint Typhoon Warning Center, Guam. In 1999, LCDR Shiels transferred to the active reserves, where he cross-rated to intelligence specialist upon completion of IS A school in Dam Neck, VA, in August 1999. LCDR Shiels was then assigned to Joint Forces Intelligence Command, where he was the leading petty officer of the asymmetric threat analysis division.

In August 2002, LCDR Shiels completed a bachelor's degree in business administration from the University of Maryland University College. In September 2002, LCDR Shiels attended Officer Candidate School in Pensacola, FL, where he received a commission as an ensign in December 2002. Upon completion of OCS, LCDR Shiels attended the Navy Supply Corp School in Athens, GA, where he graduated in December 2003.

In March 2004, LCDR Shiels reported to USS *San Antonio* (LPD17), where he served as disbursing/sales officer, food service officer, and assistant supply officer until October 2006. In November 2006, LCDR Shiels reported to Officer Training Command in Pensacola, FL, as the supply officer and class officer until October 2007, when he transitioned to Officer Training Command Newport as a class officer. In May 2009, LCDR Shiels reported to USS *Frank Cable* (AS 40) as the inventory control principal assistant and food service officer. Upon detaching from USS *Frank Cable* in November 2011, he reported to the Naval Postgraduate School in Monterey, CA, to pursue an MBA in financial management.

His personal awards include the Navy Marine Corp Commendation Medal (three awards), Navy/Marine Corps Achievement Medal (four awards), and various unit and campaign awards.

Lieutenant Commander F. Warren Sherman is a native of Memphis, TN. In December 2001, he graduated from East Carolina University with a Bachelor of Science in Business Management, with concentrations in operations management and management information systems. Commissioned from Officer Candidate School in Pensacola, FL, on July 17, 2002, he began his Supply Corps Basic Qualification Course in Athens, GA, for his first supply division officer tour.

His initial sea duty assignment was USS *Mount Whitney* (LCC-20), where he reported as the disbursing officer in June 2003. During his tour, he was TAD to be the disbursing/sales division officer onboard the USS *Barry* (DDG 52) in support of Operation Iraqi Freedom. Upon return from deployment, LCDR Sherman began training for his department head afloat tour onboard USS *Norfolk* (SSN 714), where he provided services and support for an arduous deployment in support of Operation Iraqi Freedom, where the USS *Norfolk* earned the Battle "E."

In 2007, LCDR Sherman became the branch head of Common Systems Weapons Support Team at Naval Inventory Control Point in Philadelphia, PA. He completed his life cycle logistics internship and moved to the front office.

From 2009 to 2011, LCDR Sherman reported to USS *Enterprise* (CVN 65), serving in positions as S-8 material division officer and S-1 stock control division officer. Upon fleeting up to principal assistant positions in both services and logistics, he aided services to the crew of over 5,000 with far-reaching combat logistics during a deployment for six months to the CENTCOM AOR in support of Operations Enduring Freedom and New Dawn. During his tour, *Enterprise* won the Supply Blue "E."

In 2011, he reported to the Naval Postgraduate School in Monterey, CA, to pursue a Master of Business Administration degree with a concentration in financial management.

His personal awards include three Navy and Marine Corps Commendation Medals and three Navy and Marine Corps Achievement Medals. He is a qualified naval aviation supply officer, submarine supply corps officer, and surface warfare supply corps officer.

Lieutenant Commander Sherman is married to the former Heather Judith Downey of Scotia, NY, and has two sons named Ridley Penn (4) and newborn Jasper Drake. They currently reside in Monterey, CA.

NPS-FM-13-027

ACQUISITION RESEARCH PROGRAM
SPONSORED REPORT SERIES

Analysis and Recommendation for a Fifteen Percent Cut in Space and Naval Warfare Command for Management Support Services

30 June 2013

LCDR Kurt Celis, USN

LCDR Warren Sherman, USN, and

LCDR Matthew Shiels, USN

Advisors: Simona Tick, Lecturer,
Dr. Steven Landry, Visiting Professor

Graduate School of Business & Public Policy

Naval Postgraduate School

THIS PAGE INTENTIONALLY LEFT BLANK

<h1 style="text-align:center">TABLE OF CONTENTS</h1>

LIST OF FIGURES

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF TABLES

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF ACRONYMS AND ABBREVIATIONS

BRAC	Base Realignment and Closure
C3	Command, Control, and Communications
CIPA	Capital Investment Planning Aid
CNO	Chief of Naval Operations
DoD	Department of Defense
DPAP	Defense Procurement Acquisition Policy
EPA/TOA	Extended Planning Annex/Total Obligated Authority Model
FPDS	Federal Procurement Data System
FY	Fiscal Year
GSA	Government Services Administration
LP	Linear Programming
NAVAIR	Naval Air Systems Command
NAVELEX	Naval Electronic Systems Command
NAVFAC	Naval Facilities Engineering Command
NAVMAT	Navy Material Command
NAVSEA	Naval Sea Systems Command
NAVSUP	Naval Supply Systems Command
NWCF	Navy Working Capital Fund
OMB	Office of Management and Budget
OUSD(AT&L)	Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics
PCO	Procuring Contracting Officer
PSC	Product Service Code
RHS	Right-Hand Side
S&E	Supplies and Equipment
SCOUT	Space Command Optimizer of Utility Toolkit
SPAWAR	Space and Naval Warfare Systems Command
SSP	Strategic Systems Programs

SYSCOMS   Systems Commands

VCNO   Vice Chief of Naval Operations

I. INTRODUCTION

For over 10 years, the United States has seen the national debt increase at an alarming rate. The public, Congress, and outside agencies that provide governmental oversight give greater scrutiny of government spending—specifically, spending within the Department of Defense (DoD). These continuing deficits have increased the need for more proficient capital budgeting tools to be employed by commands. For the purpose of this project, we examined the Information Dominance Systems Command of the Navy, which provides all technology-based management support services to the Navy. The Command's name is Space and Naval Warfare Systems Command, or SPAWAR. In an era of continually reduced funding, the Office of Management and Budget (OMB) is requiring a 15% reduction in spending on management support services in the fiscal year (FY) 2014 budget.

The management support services that SPAWAR provides fall under 10 project service codes (PSCs). SPAWAR believes that not all 10 of the PSCs provide equal value to the warfighter. For this reason, it does not want to merely reduce spending in all PSCs by a uniform 15%. In this MBA project, we aim to answer the following question: What amount of spending reduction would be optimally taken in each of the PSCs in order to maximize warfighter value?

In this project, we aim to develop a linear optimization decision model to use as a capital budgeting decision support tool that will aid in analyzing the PSCs identified by SPAWAR and provide recommendations to reduce spending among the PSCs in order to meet budget requirements while minimizing the impact to the warfighter and his or her overall mission. Based on the analysis of our modeling approach, we aim to provide recommendations to SPAWAR in an effort to support their goal of a 15% reduction in spending with minimal impact to SPAWAR.

THIS PAGE INTENTIONALLY LEFT BLANK

II. BACKGROUND

In this chapter, we describe the environment in which SPAWAR makes budgeting decisions and review the main challenges involved in this process. The following review is meant to provide a framework for better understanding the methodological approach and the constraints we use in the Analysis chapter.

A. SPACE AND NAVAL WARFARE SYSTEMS COMMAND (SPAWAR)

1. Origin of Space and Naval Warfare Systems Command

SPAWAR began as Naval Electronic Systems Command (NAVELEX) on May 1, 1966 (Pike, 2011). The defined mission at the time was to provide electronic systems, equipment, and command, control, and communications (C3) to the Navy and Marine Corps operating forces. NAVELEX fell under Navy Material Command (NAVMAT) until 1985.

In May 1985, the Navy underwent a large-scale reorganization that included re-evaluating NAVMAT in order to maximize resources moving into the 21st century. NAVMAT was dissolved, and NAVELEX became SPAWAR, an Echelon II command that falls directly under the Chief of Naval Operations (CNO). Other Echelon II commands under the CNO are Naval Air Systems Command (NAVAIR), Naval Supply Systems Command (NAVSUP), Naval Sea Systems Command (NAVSEA), and Naval Facilities Engineering Command (NAVFAC), as illustrated in Figure 1.
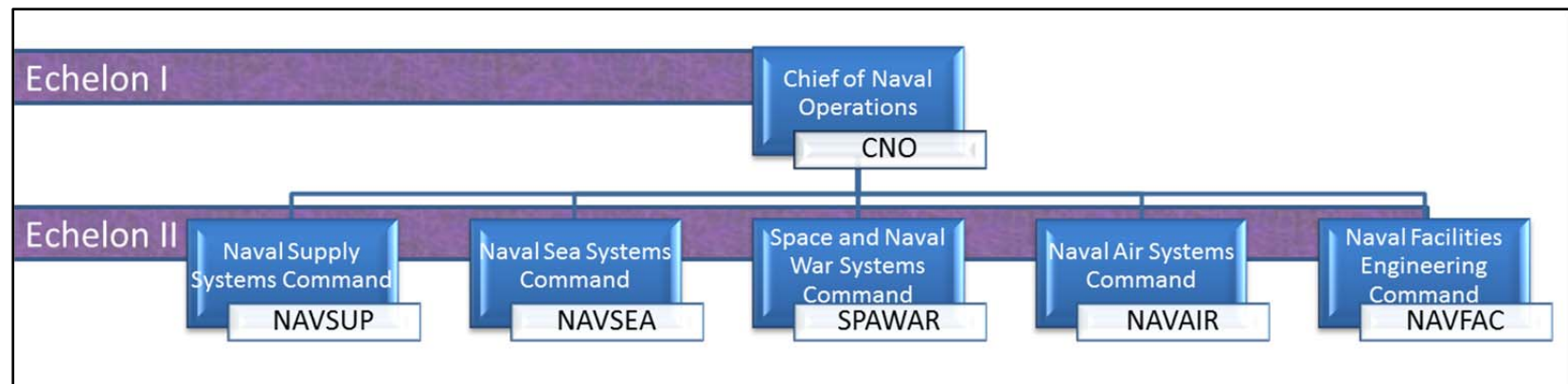
Figure 1.   Echelons of Naval Commands Under the CNO

The Navy's 1985 reorganization also resulted in new areas of responsibility for SPAWAR. In addition to C3, SPAWAR received all of Undersea Surveillance and Space Systems Command's programs. This mission change caused several established engineering commands to fall under SPAWAR's authority as well (Pike, 2011). SPAWAR relocated its headquarters to San Diego in 1997 and consolidated its three systems centers into two locations (San Diego, CA, and Charleston, SC) as part of the Base Realignment and Closure (BRAC) of 1995. In 2000, an Echelon IV command was added to the SPAWAR organization: Information Technology Center in New Orleans, LA. Space Field Activity Center in Chantilly, VA, is the most recent Echelon III command added under SPAWAR.

2. SPAWAR in the Present Day

Vice Chief of Naval Operations (VCNO) Mark Ferguson has emphasized that the Navy cannot afford to let individual commands optimize their organization at the expense of the Navy (SPAWAR, 2012). He has said that decisions should be decentralized at lower levels where we see suboptimal outcomes and higher transactional costs for the Navy as a whole. And former CNO Gary Roughead said, "SPAWAR should fully realize its role as the Navy's Information Dominance Command" (Brady, 2011, p. 1). The design of SPAWAR, as it exists today, is in line with the VCNO's comments and fulfills its role as mandated by the former CNO.

SPAWAR's current mission statement is as follows:

SPAWAR is the Navy's Information Dominance Systems Command providing capabilities in the fields of intelligence, surveillance, and reconnaissance; cyber warfare; command and control; information and knowledge management; communication systems; and enabling technologies including meteorology and oceanography. SPAWAR programs and projects cover the full life-cycle from research and development, system-of-systems engineering, test and evaluation, acquisition, installations and in-service support. SPAWAR works closely with the Fleet, Systems Commands (SYSCOMS), and Navy, Joint partners to seamlessly and effectively deliver capability by acquiring and/or integrating sensors, communications, weapons, information and control systems for existing and future ships, aircraft, submarines, and unmanned systems. (SPAWAR, 2012, p. 2)

SPAWAR maintains three program directorates consisting of two system centers located in Charleston, SC, and San Diego, CA. SPAWAR Information Technology Center remains in New Orleans, LA, now a subordinate of SSC LANT Charleston, and SPAWAR Space Field Activity Center is in Chantilly, VA, as an Echelon III command directly under SPAWAR, as illustrated in Figure 2. SPAWAR is the Navy's information systems dominance command and employs nearly 9,000 active duty and civil service employees. SPAWAR is the information technology provider and the technical authority for the entire Navy.
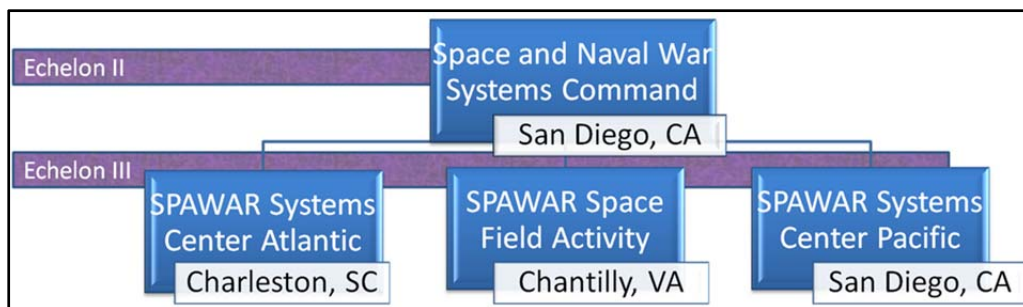
Figure 2.   Echelons of Naval Commands Beneath the SPAWAR

Funding for SPAWAR is unlike most other federal agencies in that some of its commands do not receive direct funding from Congress via annual appropriations. SPAWAR San Diego and SPAWAR SSC LANT Charleston are both Navy Working Capital Fund (NWCF) organizations. This means that these commands operate similarly to a civilian company. However, an important difference between NWCF organizations and civilian organizations is that the goal of a NWCF organization is to break even rather than generate a profit. The continual flow process of a working capital fund is illustrated in Figure 3.
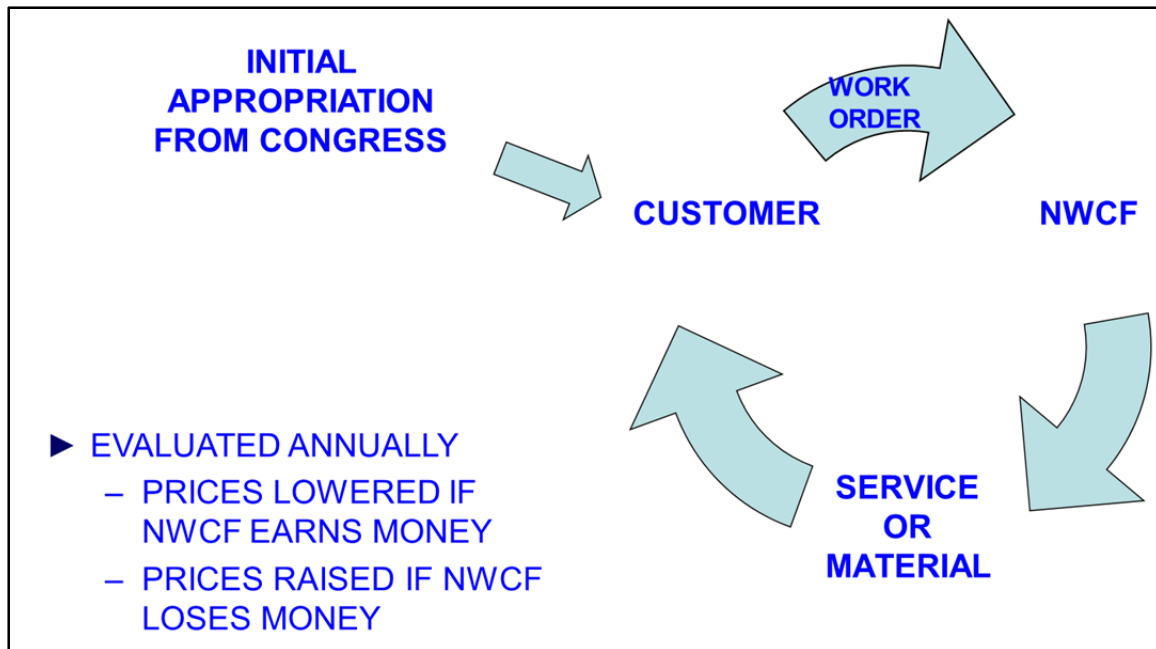
Figure 3.   Flow of Working Capital in NWCF Organizations

A NWCF organization receives a one-time appropriation from Congress and then uses the revenue from its products or services to keep the organization operating. A customer, typically a naval command or other federal agency, requests a service or product from SPAWAR. The revenue from this transaction goes into the NWCF, and then the service or product is provided to the customer. This cycle is continuous and is not bound by fiscal year constraints. The NWCF organization must recover all of the costs of doing business in the form of revenue from its products and services. If too much money is earned in a year, the prices can be lowered for the following year in order to maintain a zero profit.

B.   PRODUCT SERVICE CODES

The DoD codifies its spending categories using PSCs. These spending categories are used by all contracting activities of the federal government in recognizing supplies and equipment (S&E) and services under contract. The Government Services Administration (GSA) manages the PSCs by the *Federal Procurement Data System Product and Service Codes Manual* (General Services Administration [GSA] Office of Government-wide Policy, 2011, p. 1).

This type of classification is easy to use because it only involves four groups (i.e., portfolio groups, portfolios, portfolio categories, and portfolio subcategories) but is also generally defined by the descriptions of S&E and services bought and paid. PSC is a different classification because it does not pertain to the acquisition life cycle or involve the association doing the purchasing. Contracting entities select PSCs—as opposed to the methods used by other organizations—because they are universally known, easy, and reliable. Other characteristics identified in S&E and services portfolio groups contain

- the origin and kind of equipment, services, and supplies;
- the work level; and
- the planned claim.

All entities involved will use this method to retain continuity throughout the DoD in order to further manage funds and determine the worth of the S&E and services developed, purchased, and obtained to figure out patterns and determine metrics for management to measure (GSA Office of Government-wide Policy, 2011, p. 1).

1. Portfolio Group Spend Analysis

In the strategic sourcing process, a portfolio group spend analysis is the initial phase of creating a thorough judgment. This analysis gives the manager a wealth of information regarding the amount of money and resources being allocated, the methods being used, and the performance metrics being completed. With this information, the analysis can identify cost avoidance, employ best management practices, and take notice of buying tendencies (GSA Office of Government-wide Policy, 2011, p. 1).

2. Portfolio Management

Defense Procurement Acquisition Policy (DPAP) conducts the portfolio group spend analysis. Overall, the Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics (OUSD[AT&L]) manages the portfolios, along with performing the framework at DoD activities (GSA Office of Government-wide Policy, 2011, p. 1).

In September 2010, the OUSD(AT&L) issued a mandate to further enhance the money allocated to defense. Furthermore, it categorized the spending tendencies into nine service portfolio groups and 40 service portfolios. This list is associated with Figure 4,

which shows the "taxonomy" of these service PSCs. A breakdown of the nine service portfolio groups and the number of codes, categories, and portfolios in these service portfolio groups is in Figure 5. SPAWAR uses the portfolio groups of Knowledge Based Services and Electronic & Communication Services; a list of the service portfolios, along with their PSCs and titles, are defined in Figures 6 and 7. Table 1 is a list of the PSCs, along with their definitions, that SPAWAR uses. These figures and table give the DoD a path for strategic sourcing and give us a basis for SPAWAR's spending habits that lead to better management practices (Assad, 2010, p. 1).

PSCs have four characters with research and development, services have a letter in the first character, and products have a digit in the first character. SPAWAR uses service codes that either have a D or an R in the first character. D is used for information technology and telecommunications, and R is used for professional, administration, and management (Defense Procurement and Acquisition Policy [DPAP] Defense Pricing, 2012, p. 10).

There could be a time where multiple PSCs are on a contract or job order. In these cases, the procuring contracting officer (PCO) assigns whatever PSC has the most money allocated (DPAP Defense Pricing, 2012, p. 6).
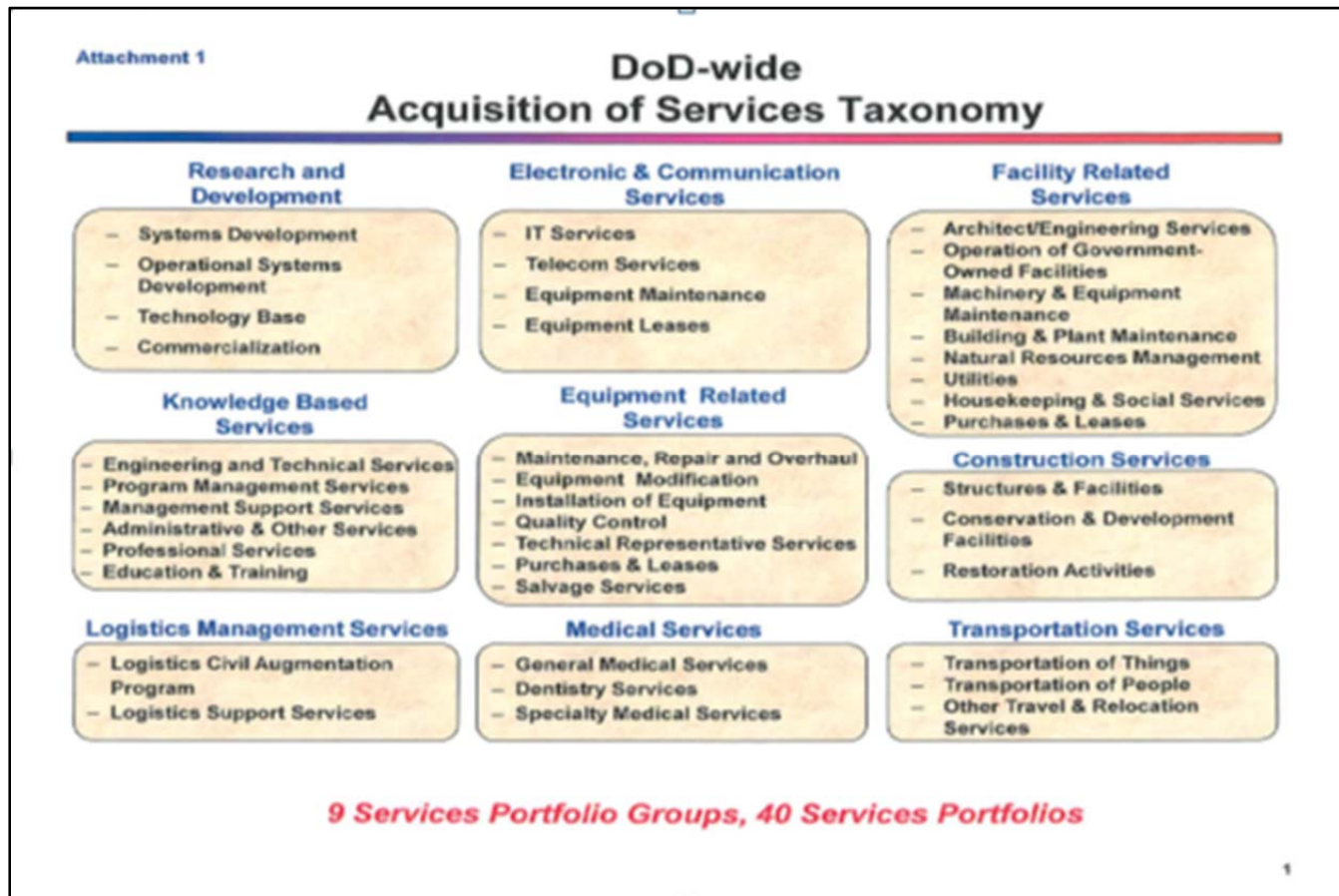
Figure 4.   DoD-Wide Acquisition of Services Taxonomy
(Assad, 2012, p. 2)

Figure 5.   Service Portfolio Groups
(Assad, 2012, p. 4)

Figure 6.   PSC Definitions
(Assad, 2012, p. 8)

Figure 7.   PSC Definitions (Continued)
(Assad, 2012, p. 9)

Table 1.   SPAWAR Product Service Code Definitions

(based on DPAP Defense Pricing, 2012, pp. 58–315)

Category D Information Technology and Telecommunications
Category D3 Information Technology and Telecommunications
D302	IT and Telecom—Systems Development
D307	IT and Telecom—IT Strategy and Architecture
D310	IT and Telecom—Cyber Security and Data Backup
	Includes: Information Assurance, Virus Detection, Network Management, Situational Awareness and Incident Response, Secure Web Hosting, Backup and Security Services
D314	IT and Telecom—System Acquisition Support
	Includes: Preparation of Statement of Work, Benchmarks, Specifications, etc.

Category R Support (Professional/Administrative/Management)
Category R4 Support—Professional

R408	Support—Professional: Program Management/Support
	Includes: Situations in which the contractor is solely responsible for program management as well as situations in which the contractor provides program management support to a government program manager
	Excludes: Program Evaluation/Review/Development (PSC R410), Contract/Procurement/Acquisition Support (PSC R707)
R413	Support—Professional: Specifications Development
R423	Support—Professional: Intelligence
R425	Support—Professional: Engineering/Technical
	Includes: Systems Engineering, Technical Assistance, and other services used to support the program office during the acquisition cycle
R497	Support—Professional: Personnel Services Contracts
R707	Support—Management : Contract/Procurement/Acquisition Support

Combined R414, R421, R425 Based on FAR Definition

SPAWAR's use of the PSC is the foundation to take into our Methodology, Analysis, and Recommendations chapters. The 10 PSCs used by SPAWAR are the 10 PSCs that we analyze in developing the linear programming model in this MBA project.

THIS PAGE INTENTIONALLY LEFT BLANK

III. LITERATURE REVIEW

In this chapter, we review the most relevant and recent studies that address the issue of developing and using integer or linear programming as a means for capital budgeting decision support. This chapter highlights the contribution that this project aims to bring relative to existing studies.

The OMB's requirement for SPAWAR to reduce spending on management services for FY2014's budget fits the model of most capital budgeting questions, including the following: How much of what resources should be bought to maximize our utility with a limited amount of money? In SPAWAR's case, the question is as follows: How much should be spent on each of the 10 PSCs in FY2014 while providing the greatest return to the warfighter? There are a number of related studies on capital budgeting and the use of decision models such as linear programming models and integer-linear programming models that are utilized in order to help make budgeting decisions. The following studies help to provide background information on capital budgeting and offer ways to develop and use linear programming models that will result in making the correct budgeting decisions.

In his 1999 thesis, Richard J. Field of the Naval Postgraduate School analyzed the use of the Capital Investment Planning Aid (CIPA), which is an integer-linear programming model, in order to aid in planning capital budgeting for naval forces. The CIPA model is designed to lengthen the Extended Planning Annex/Total Obligated Authority Model (EPA/TOA). Field's (1999) study made every effort to use a model that accounts for the same budgetary restrictions, force level requirements, and restriction and requirements of industrial bases and potential penalties found in the EPA/TOA. The use of the EPA/TOA allowed for a set of given constraints to be used in the development of the CIPA model. We examined Field's study and utilized information within his thesis to help provide insight as to how we could initiate the development of a linear programming model with multiple decision variables and constraints that could be used as our recommendation for SPAWAR's current situation.

Newman, Brown, Dell, Giddings, and Rosenthal's (2000) thesis provided a technical report on the Air Force's Space Command Optimizer of Utility Toolkit

(SCOUT) used for capital budgeting. The SCOUT is "a mixed integer linear program that selects a set of concepts, the dates of inception and discontinuance of use, and the number of concept launches by type and year which best satisfies the Air Force Space Command's operational tasking requirements" (Newman et al., 2000, p. 1).

The SCOUT's objective function is to minimize costs that do not result in an increase in performance. These costs are things such as penalties for not meeting performance requirements, violating budget constraints, or other penalties. The SCOUT categorizes constraints into four categories: budget constraints, performance requirements, precedence requirements, and interdependency requirements. Newman et al.'s (2000) thesis helped us to develop constraints for our model through a categorization process.

In his 1992 Naval Postgraduate School thesis, Scott Donahue developed an optimization model to assist the Army Training and Doctrine Command to select what should be included in its *Long Range Army Materiel Requirements Plan*. The objectives of the model were to improve the Army's warfighting capability while maintaining equilibrium between different mission areas. Donahue's model identified a number of constraints, including budget restrictions, project requirements, incremental funding requirements, and project relationships that can be mutually exclusive, complementary, or subordinate. This study helped us in the development of our model because it provided an approach on how to assign weighted values to different decision variables without having a tangible number.

Gerald Brown's (2004) thesis, *Optimization-Based Military Capital Planning*, "surveys the history of optimizing civilian and military capital plans and present prototypical models exhibiting features that render these models useful for real world decision support" (Brown, 2004, p. iv). Brown's study helped us to identify which decision model would be applicable to our research question based on our objective function and constraints.

In the preceding studies, the constraints used in the linear programming models were defined. In the development of the linear programming model used in this study, the constraints are not as defined. The process used to identify and define the decision variables within our model is what makes this study stand out from past studies.

IV. METHODOLOGY

The following chapter provides a review of the methodology that we utilize in this study to provide SPAWAR with a recommendation for spending reduction. The chapter defines what linear optimization decision modeling is, identifies types of decision models, and explains the three-step process to develop a decision model since they are used later on in our approach.

Decision modeling is defined as "a scientific approach to managerial decision making" (Balakrishnan, Render, & Stair, 2013). Decision modeling removes personal bias, emotion, or guesswork from the decision-making process by the use of a mathematical model to assist in the decision-making process. Decision models are classified into two major categories: deterministic models and probabilistic models. The type of model is "based on the type and nature of the decision-making problem environment under consideration" (Balakrishnan et al., 2013).

A. DECISION MODELING

According to *Managerial Decision Modeling* by Balakrishnan et al. (2013), "deterministic models assume that all the relevant input data values are known with certainty; that is, they assume that all the information needed for modeling a decision making problem environment is available, with fixed and known values" (Balakrishnan et al., 2013, p. 2). The use of a deterministic decision model provides an output that will react and change in a consistent and predictable way given a known change in one of the input variables. Managers at manufacturing companies such as Scotts use several raw materials to produce different kinds of fertilizer; they would be able to use a deterministic model to help decide what the best product mix would be in order to achieve a desired profit level when given a limited amount of available raw material.

Probabilistic models, also known as stochastic models, are used when there is some level of uncertainty with the values of the input data before a decision is made. It is important for the decision process to incorporate the level of uncertainty or the variable into the model. An example of a probabilistic model would be one that provides a decision on which stock to include in an investment portfolio. It is vital for managers to

understand that the results from a probabilistic model are not guaranteed but provide a base for making decisions by also taking into account these uncertainties.

B.   DECISION MODELING STEPS

In *Managerial Decision Modeling*, Balakrishnan et al. (2013) broke the decision modeling process into three separate steps: formulation, solution, and interpretation. Each one of the steps of the decision model has its own set of components. These components have an iterative process between them, and a change in one component can affect the inputs of another component. If the results found while testing the solution do not work, then that model may have to be redeveloped. Figure 8 provides a graphic view of the steps.
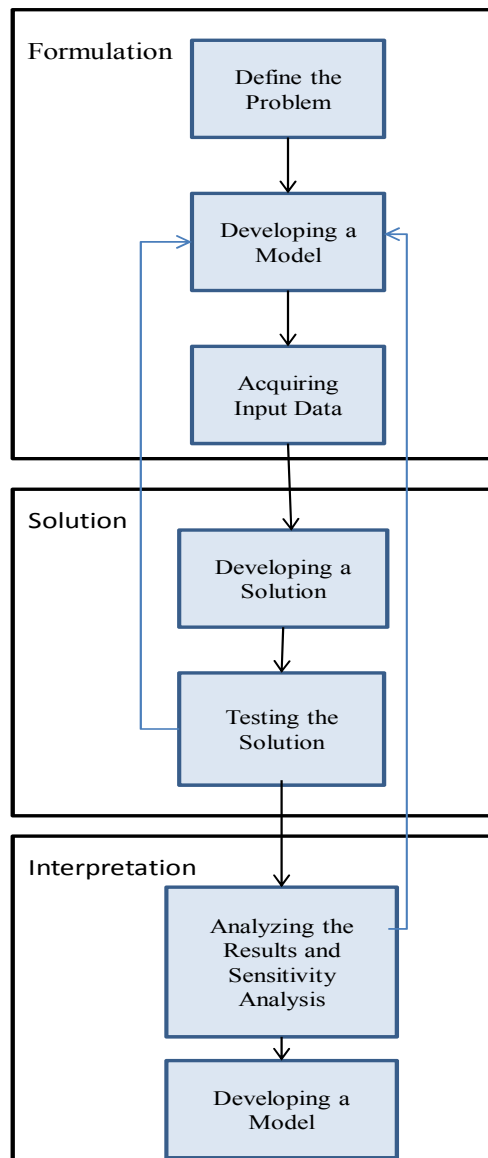
Figure 8. A Graphic View of the Decision Modeling Process
(Balakrishnan et al., 2013)

1. Formulation

Formulation is the method by which each part of the problem is put into mathematical terms. Formulation provides the foundation on which the decision model is built and is essential to a well-thought-out model because a poorly formulated decision model will provide results that will not lead to the optimal solution. Balakrishnan et al.

(2013) divided the formulation process into three components: defining the problem, developing a model, and acquiring input data.

The first component of the formulation process is to define the problem. A clear and concise explanation of what question the model is answering is essential because the explanation will provide which direction to take in developing the rest of the decision model.

Defining the problem addresses the main issues that are at the center of the problem. Once the problem has been defined, the next component of the formulation is to develop a decision model.

Decision modeling differs from other types of models, such as schematic models or scale models, because it is a mathematical model built on a set of mathematical relationships. Decision models express a dependent variable as a function of one or more independent variables. Consider a simple mathematical model for profit:

$$Profit = Revenue - Expense \qquad (1)$$

In mathematical terms, this functional relationship would be expressed as

$$Profit = f(Revenue, Expenses) \qquad (2)$$

In plain language, this expression would mean "profit is a function of revenue and expense" (Ragsdale, 2007, p. 5). In this model, profit is the dependent variable, and revenue and expenses—as functions of profit—are the independent variables.

$$Y = f(X1, X2) \qquad (3)$$

The function of the independent variable is the mathematical expression of the problem definition. The relationship of the dependent variable to the independent variable can be expressed as equations or inequalities, and there is no limit to the number of independent variables affecting the relationship. After the model has been developed, the input data needs to be acquired in order to be used in the model.

Input data can be acquired from a variety of different sources, ranging from financial reports to interviews to production data. No matter where the data for the model is collected from, it is important to collect good data. No matter how good the decision model is, if inaccurate data is put into the model, the result is incorrect, which can lead managers to make a decision that may not correct the problem and could possibly lead to greater issues. The acquiring of data marks the last component in the formulation step.

2. Solution

The solution step is where the data is inputted into the decision model and a best solution for the model is found. The solution step is broken down into two components: developing the solution and testing the solution. Developing the solution is the inputting of data into the model, which will generate the solution. Once this is done, the solution must then be tested to ensure that it is correct. Testing the solution can be accomplished by inputting data from another source and doing a statistical comparison of the two outputs to ensure accuracy. If inaccuracies are found, then the data used may not be accurate; likewise, if the solution does not answer the problem, then the model itself may not accurately address the problem. When inaccuracies occur, the formulation process must be re-examined to ensure that the model answers the problem and that the data being used is accurate.

3. Interpretation and Sensitivity Analysis

The third step of the decision modeling process is interpretation and sensitivity analysis. The first component of this step is analyzing the results of the sensitivity analysis, and the second component is implementing the results. These components depend on how the user of the model views the model's results and how he or she chooses to use those results.

Analyzing the results begins with determining what impact the solution will have on the organization. Sensitivity analysis is used to determine how much the results of the model will change based on a given change in the input data. This is an important part of the decision modeling process because a small change in an input may significantly change the model output.

The final component of the decision modeling process is implementing the results. The implementation process, in most cases, is almost as important as the decision model itself. Implementation should be closely monitored to ensure that there are no changes that will need to be made and that the end results of the implemented decision are expected.

C.   LINEAR PROGRAMMING

We use a linear programming model approach to provide SPAWAR with a recommendation of which PSCs to adjust in order to reduce spending. Linear programming is a type of deterministic model that has the ability to apply to a wide spectrum of management questions, ranging from transportation or production to budgeting or human resources, along with a whole host of other areas. Therefore, developing and using a linear programming model follows the three steps of the decision modeling process.

As stated by Balakrishnan et al. (2013) in *Managerial Decision Modeling*, every linear programming model has four distinct properties and four requirements, or assumptions, that are identified.

1. Properties

- All problems seek to maximize or minimize an objective, referred to as the objective function. The objective function must be clearly stated and defined mathematically so that it can provide the optimal solution to the problem.

- Constraints limit the degree to which the objective can be obtained. They provide the limitations of a resource against which the objective function is maximized or minimized. A linear programming model usually includes non-negativity constraints, which ensure that the decision variables in the model cannot take on negative numbers.

- There must be more than one solution available. There also must be more than one answer to the problem because if there were only one answer, then the linear programming model would not be needed.

- Mathematical relationships are linear. The objectives and constraints in the linear programming problems must be able to be expressed in terms of linear equations or inequalities. (Balakrishnan et al., 2013)

2. **Requirements/Assumptions**

- It is assumed that a condition of certainty exists and that the numbers used in the objective function and the constraints are correct during the three-period range used in the model.

- It is also assumed that proportionality exists between the dependent and the independent variables in the objective function. Therefore, if the requirement to build a single item calls for $100 of material, then it would cost $1,000 of the material to build 10 units.

- The next assumption is that the total of all activities equals the sum of the individual activities; this is known as additivity. If a box is being made and it costs $10 for wood and $5 for glue, the total cost of the box must be $15.

- The last assumption is that the solution may be divided into a fraction; this is the divisibility assumption. (Balakrishnan et al., 2013)

Decision modeling is an approach to decision-making that helps to remove biases by applying a mathematical formula (objective function) to the decision process. The result of the objective function is based on the constraints of the independent variable (decision variables). The decision-maker completes an analysis on the results of the model and uses those results to produce a recommendation to a given question. In the next chapter, we provide detailed information about the three-step decision modeling process that is used to develop the linear programming model and the properties and requirements of the linear programming model used in this project.

V. PROJECT DATA

In this chapter, we provide a detailed description of the data we used as an input into the linear programming model in this study. We also present the location of the source of the data and the information that makes up the data. We also discuss the means we used to analyze the data and the resulting information we gained from the analysis. We explain why we ultimately chose the methods of data analysis that we use in order to gain the information necessary to develop the objective function and decision variables in the LP model.

A.   DATA SOURCE

SPAWAR's Federal Procurement Data System (FPDS) administrator provided all of the data we used to develop the objective function and the decision variable constraints for the linear programming model in this study. The FPDS is a single source repository for data on government contracting. All contracts that have an estimated value of over $3,000 for all government agencies are required to be entered and maintained in the FPDS.

B.   FPDS DATA OUTPUT INFORMATION

The data from the FPDS used to develop the linear programming model in this study is all spending data from FY2010 through FY2012 on management services contracts by SPAWAR. Each line item of data is a contract written by a command falling under SPAWAR for a given PSC during the fiscal year and the total money value of that contract. Table 2 shows a sample line item of the data used.

Table 2.   Sample of FPDS Data

FPDS Award PIIN Extended	Org Level 1	Org Level 5	Issue Ofc Cd - Current	Prod or Svc Cd	Prod or Svc Name	Signed Dt FY	Obligated Amt Change	Current Contract Value
N00030-10-C-0009	SSP	USN-STRATEGIC SYSTEMS PROGRAMS	N00030	R425	ENGINEERING TECHNICAL SERVICES	2010	$36,118,799.00	$38,398,700.00

The information provided in each line item of data is the contract number, the command that wrote the contract, the PSC, the year the contract was awarded, and the value of the contract. The contract number is found under FPDS Award PIIN Extended. The command issuing the contract is broken down into both Organizational Level 1 (Org Level 1) and Organizational Level 5 (Org Level 5) commands. Because SPAWAR is an Org Level 1 command, we only needed to analyze the data at that level. SPAWAR is broken into two Org Level 1 commands in the FPDS. To capture all of SPAWAR spending on management services, all contract data must be accounted for by SPAWAR and Strategic Systems Programs (SSP). The data provides the PSC by both code and name. The fiscal year in which the contract was signed is found under the Signed Date Fiscal Year (Signed Dt FY) field. Current Contract Value provides the final value of the obligation for the contract.

C. DATA ANALYSIS

To analyze these 18,600 line items of data from FY2010 to FY2012, we first began by identifying what information in the data is essential to determine SPAWAR spending on PSCs. We grouped the data by fiscal year and PSCs. In FY2012, PSCs R414 and R421 were combined with PSC R425. To account for the merger of the three PSCs while analyzing the data, we added the spending for PSCs R414 and R421 into PSC R425 for FY2010 and FY2011. Table 3 shows the results of this combination and the grouped data that we used for our analysis.

Table 3.   Spending on Management Services by PSC

Spending on Management Services by PSC										
Year	D302	D307	D310	D314	R408	R413	R423	R425	R497	R707	Total
2010	$107,611,250.09	$59,107,229.40	$434,754.36	$19,265,029.07	$273,258,071.55	$0.00	$0.00	$729,025,129.50	$0.00	$0.00	$1,188,701,463.97
2011	$82,778,499.63	$116,663,086.34	$3,200,170.33	$34,623,749.07	$276,555,368.51	$40,000.00	$0.00	$849,916,666.37	$0.00	$0.00	$1,363,777,540.25
2012	$82,253,784.36	$113,109,109.62	$2,509,549.82	$32,206,286.64	$190,362,881.78	$1,350,718.00	$0.00	$540,445,175.13	$146,360.55	$4,088,696.35	$966,472,562.25

The goal for our data analysis was to determine a weighted value for each of the PSCs that proxies the relative ranking in value added for PSCs. The weights are to be used in the optimization model as coefficients in the objective function and in constraints. We began our analysis by plotting the data for each of the PSCs on a scatter plot to compare how spending on PSCs from fiscal year to fiscal year behaved. This analysis shows that there was not a straight-line percentage increase or decrease in spending from one fiscal year to the next. The complete set of scatter plots is found in Appendix A. Since spending changes for each PSC were independent, we concluded that each of the PSCs must provide a different value to the mission of the organization. This value would be the coefficient for the decision variables in the objective function. A more detailed description of the method we used to determine the value provided by each PSC is discussed in the following chapter.

To develop a set of constraints, we determined a maximum and minimum spending limit for each of the PSCs. The first step in the process was to estimate what FY2014 spending would be based on the data. We began by simply computing an average of the spending for each of the PSCs over the three-year period from FY2010 through FY2012. The results of a simple average of each of the PSC spending levels do not take into account any type of spending trends, as can be seen by the results in Table 4.

Table 4.   **Average Spending on Management Services by PSC**

Average Spending on Management Services by PSC											

Year	D302	D307	D310	D314	R408	R413	R423	R425	R497	R707	Total
2010	$107,611,250.09	$59,107,229.40	$434,754.36	$19,265,029.07	$273,258,071.55	$0.00	$0.00	$729,025,129.50	$0.00	$0.00	$1,188,701,463.97
2011	$82,778,499.63	$116,663,086.34	$3,200,170.33	$34,623,749.07	$276,555,368.51	$40,000.00	$0.00	$849,916,666.37	$0.00	$0.00	$1,363,777,540.25
2012	$82,253,784.36	$113,109,109.62	$2,509,549.82	$32,206,286.64	$190,362,881.78	$1,350,718.00	$0.00	$540,445,175.13	$146,360.55	$4,088,696.35	$966,472,562.25
Average	$90,881,178.03	$96,293,141.79	$2,048,158.17	$28,698,354.93	$246,725,440.61	$463,572.67	$0.00	$706,462,323.67	$48,786.85	$1,362,898.78	$1,172,983,855.49

For example, the average of the spending results for PSC R408 is $246,725,440, which is an increase in spending from FY2012 by more than $56 million. The data, however, clearly shows that spending for PSC R408 has a downward trend.

To account for the spending trends from fiscal year to fiscal year, we calculated a three-period weighted average. The weights we chose for the weighted three-period average are 50% for FY2012, 35% for FY2011, and 15% for FY2010. These weights put more emphasize on the most current data and less emphasize on the oldest data, which is a standard approach in forecasting. The results of the three-period weighted averages help to account for spending changes over time but still have some of the same issues that were found when using a simple average. Using the weighted average to calculate FY2014 spending would result in a value that was less than FY2012's value when spending increased each year. The results of the three-period weighted averages can be found in Table 5.

Table 5.   Three-Period Weighted Average of Spending by PSC

	Year	D302	D307	D310	D314	R408	R413	R423	R425	R497	R707	Total
Spending on Management Services by PSC 3 Period Weighted Average												
	2010	$107,611,250.09	$59,107,229.40	$434,754.36	$19,265,029.07	$273,258,071.55	$0.00	$0.00	$729,025,129.50	$0.00	$0.00	$1,188,701,463.97
	2011	$82,778,499.63	$116,663,086.34	$3,200,170.33	$34,623,749.07	$276,555,368.51	$40,000.00	$0.00	$849,916,666.37	$0.00	$0.00	$1,363,777,540.25
	2012	$82,253,784.36	$113,109,109.62	$2,509,549.82	$32,206,286.64	$190,362,881.78	$1,350,718.00	$0.00	$540,445,175.13	$146,360.55	$4,088,696.35	$966,472,562.25
3 Period Weighte		$86,241,054.56	$106,252,719.44	$2,440,047.68	$31,111,209.86	$232,964,530.60	$689,359.00	$0.00	$677,047,190.22	$73,180.28	$2,044,348.18	$1,138,863,639.81

A more accurate estimate for FY2014 spending is obtained through a linear trend estimation technique. Assuming that the relation between spending and time (measured in years) is linear, we can estimate annual spending for FY2014 as a linear function of time. The intercept and the slope are estimated based on available historical data for the past three years, using the linear regression model $Y = a + b(x)$, where Y is the spending in any given year and x is the year. The variable a is the intercept of the linear relations, and the variable b is the slope. The outcomes of projected FY2014 spending are found in Table 6. We provide a more detailed description of this process in the following chapter.

Table 6.   Spending on Management Services by PSC

Year	D302	D307	D310	D314	R408	R413	R423	R425	R497	R707	Total
2010	$107,611,250.09	$59,107,229.40	$434,754.36	$19,265,029.07	$273,258,071.55	$0.00	$0.00	$729,025,129.50	$0.00	$0.00	$1,188,701,463.97
2011	$82,778,499.63	$116,663,086.34	$3,200,170.33	$34,623,749.07	$276,555,368.51	$40,000.00	$0.00	$849,916,666.37	$0.00	$0.00	$1,363,777,540.25
2012	$82,253,784.36	$113,109,109.62	$2,509,549.82	$32,206,286.64	$190,362,881.78	$1,350,718.00	$0.00	$540,445,175.13	$146,360.55	$4,088,696.35	$966,472,562.25
Projected 2014	$52,844,979.43	$177,295,962.12	$5,160,351.36	$48,110,241.28	$122,382,655.96	$2,489,649.67	$0.00	$423,592,392.11	$268,327.68	$7,495,943.31	$839,640,502.91

The information obtained from the cost estimation provides either a spending ceiling or a spending floor for each of the PSCs to be used as a constraint for each of the decision variables. A second constraint for each decision variable is necessary to set a spending range for each PSC. The analysis of the scatter plots shows that the spending does not increase or decrease at a constant rate for all PSCs. This suggests that SPAWAR is more willing to take a greater spending reduction in some PSCs in order to have more funds available in another PSC.

The information can be found by calculating the percentage of management services spending on each PSC in a given fiscal year and the FY2014 projected spending based on the cost-estimation relationship. In comparing these results, it is evident that there may be a significant variation in the percentage of spending on some of the PSCs from fiscal year to fiscal year. Due to this variation, we used a percentage of total management services spending to constrain the decision variables that would not provide an accurate result. The calculated spending percentages for the PSCs can be found in Table 7.

Table 7.   Percentage of Total Management Service Spending

Pecent of Total Management Services Spending												
Year	D302	D307	D310	D314	R408	R413	R423	R425	R497	R707	Total	
2010	9.05%	4.97%	0.04%	1.62%	22.99%	0.00%	0.00%	61.33%	0.00%	0.00%		100.00%
2011	6.07%	8.55%	0.23%	2.54%	20.28%	0.00%	0.00%	62.32%	0.00%	0.00%		100.00%
2012	8.51%	11.70%	0.26%	3.33%	19.70%	0.14%	0.00%	55.92%	0.02%	0.42%		100.00%
2014	6.29%	21.12%	0.61%	5.73%	14.58%	0.30%	0.00%	50.45%	0.03%	0.89%		100.00%

Analyzing the percentage of spending for a PSC in one fiscal year to the next provides insight into the willingness of SPAWAR to prioritize spending on one PSC compared to another. With this information, we then calculated an annual percentage change in spending in a PSC from fiscal year to fiscal year. The data resulted in the information presented in Table 8.

Table 8.   Change in Percentage of Spending by PSC

Change in Percent of Spending										
Year	D302	D307	D310	D314	R408	R413	R423	R425	R497	R707
2011	-23.08%	97.38%	636.09%	79.72%	1.21%	0.00%	0.00%	16.58%	0.00%	0.00%
2012	-0.63%	-3.05%	-21.58%	-6.98%	-31.17%	3276.80%	0.00%	-36.41%	0.00%	0.00%

We used this information to calculate a weighted reduction in spending for each of the PSCs to use as the second decision variable constraint. In the following chapter, we detail the development of the weighting factor and calculation of the constraint.

We used a number of different methods to analyze the FPDS data provided by SPAWAR to accurately develop constraints for the decision model in our LP model. The following chapter provides a detailed description of the development of each of the parts included in the linear programming model, the implementation of the model, and analysis of the model results.

VI. A LINEAR PROGRAMMING MODEL FOR SPAWAR

In this chapter, we provide a detailed description of the linear programming model developed to provide SPAWAR with a budget recommendation for FY2014 spending on management services. We use our problem definition to identify the objective function and decision variables. Once the objective function and decision variables are identified, we define a set of constraints for each of the decision variables. We then implement the mathematical LP model into Microsoft Excel's Solver to obtain the optimization results. We analyze these results and conduct sensitivity analysis to identify how robust the optimization results are to changes in the input variables.

A. DEFINING THE COMPONENTS OF THE LINEAR PROGRAMMING MODEL

The process of developing the LP model begins by defining the problem. The problem facing SPAWAR is the need to reduce spending on management services by 15% annually from the FY2011 spending level in 2014. As discussed in our Introduction chapter, SPAWAR's spending on management services spreads among 10 PSCs. Not all of the PSCs provide the same amount of value to the warfighter. For this reason, SPAWAR does not want to take a straight 15% reduction across all of the PSCs.

1. Decision Variables

The decision variables for the LP model are the variables that can be controlled in a management decision. They are essentially the answer to the question that is defined by the objective function and are also known as controllable input variables. In the model developed for SPAWAR, the decision variables are the amount of money that will be spent on each of the PSCs in FY2014.

D302 = The amount of dollars to spend on PSC D302 in FY2014

D307 = The amount of dollars to spend on PSC D307 in FY2014

D310 = The amount of dollars to spend on PSC D310 in FY2014

D314 = The amount of dollars to spend on PSC D314 in FY2014

R408 = The amount of dollars to spend on PSC R408 in FY2014

R413 = The amount of dollars to spend on PSC R413 in FY2014

R423 = The amount of dollars to spend on PSC R423 in FY2014

R425 = The amount of dollars to spend on PSC R425 in FY2014

R497 = The amount of dollars to spend on PSC R497 in FY2014

R707 = The amount of dollars to spend on PSC R707 in FY2014

2.   Objective Function

With the problem defined, we can begin developing a LP model. The first step is to identify an objective function for the LP model. The objective function of the model is to maximize the value of spending on PSCs.

$$Z \leq f\left(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10,}\right) \tag{4}$$

The dependent variable Z is the value provided by the total spending on all PSCs as a function of the independent variables X multiplied by their coefficients. The independent variables in the equation are the decision variables within the LP model. From this point forward, the dependent variables are referred to as decision variables.

The coefficients of the decision variables in the objective function are the weighted value provided by each of the PSCs to SPAWAR's mission. To calculate this value, we calculated a three-period weighted average for each of the PSCs. A weight of 15% was given to FY2010, 35% to FY2011, and 50% to FY2012. We then divided the weighted average by the total weighted spending, resulting in the percentage of spending on each of the PSCs. We assigned this value as the coefficient for each of the decision variables. Table 9 shows the calculated three-period weighted average and the percentage of weighted spending for each PSC.

Table 9.   Percentage of Three-Period Weighted Average Spending on Management Services by PSC

					Spending on Management Services by PSC 3 Period Average						
Year	D302	D307	D310	D314	R408	R413	R423	R425	R497	R707	Total
2010	$107,611,250.09	$59,107,229.40	$434,754.36	$19,265,029.07	$273,258,071.55	$0.00	$0.00	$729,025,129.50	$0.00	$0.00	$1,188,701,463.97
2011	$82,778,499.63	$116,663,086.34	$3,200,170.33	$34,623,749.07	$276,555,368.51	$40,000.00	$0.00	$849,916,666.37	$0.00	$0.00	$1,363,777,540.25
2012	$82,253,784.36	$113,109,109.62	$2,509,549.82	$32,206,286.64	$190,362,881.78	$1,350,718.00	$0.00	$540,445,175.13	$146,360.55	$4,088,696.35	$966,472,562.25
3 Period Weighted Average	$86,241,054.56	$106,252,719.44	$2,440,047.68	$31,111,209.86	$232,964,530.60	$689,359.00	$0.00	$677,047,190.22	$73,180.28	$2,044,348.18	$1,138,863,639.81
% of Weighted Average Spending	7.57%	9.33%	0.21%	2.73%	20.46%	0.06%	0.00%	59.45%	0.01%	0.18%	100.00%

3. Defining the Constraints

Now that the objective function for the LP model has been identified, we set the parameters that affect the decision variables. The decision variables' parameters are the constraints that each of the decision variables must meet. We began the process of identifying the constraints for the LP model by asking SPAWAR the following questions.

- Is there a percentage distribution of spending that SPAWAR wants to see for each of the PSCs?

- Is there a priority order for the PSCs?

- Is there a budget for the PSCs set for each of the five commands that make up total SPAWAR spending?

- Is there a maximum number of contracts that can be written against a given PSC?

The answers to these questions helped to develop the constraints for the decision variables in the LP model. SPAWAR values three of the PSCs more highly than the rest of the PSCs because they have a more direct impact on a command's ability to complete their mission.

The first constraint is the total dollar value for spending to achieve the 15% reduction. We calculated this value by using the following formula:

$$Z \leq (\$FY2012 \times .85 \times .85) \tag{5}$$

In FY2012, SPAWAR spent $966,472,562 on the PSCs that are required to be cut. The target budget amount for FY2014 is calculated by inputting this number into the preceding equation.

$$\$698,276,426 \leq (\$966,472,562 \times .85 \times .85) \tag{6}$$

The next set of constraints is that SPAWAR does not want to reduce spending on PSCs D302, D307, and D310. This and the spending reduction requirement are the only constraints that SPAWAR directly requires. All other constraints for the decision variables would need to be identified through the analysis of spending data.

Through data analysis, we developed a range that spending for each PSC must fall into by setting spending ceilings and spending floors for each of the 10 PSCs to be used as constraints in the LP model.

To set a spending ceiling and floor for the PSCs, we began by using the FY2010, FY2011, and FY2012 data to estimate projected spending totals for FY2014. We calculated intercept and slope for each of the PSCs' spending data and used the formula to project spending levels in FY2014.

$$Y = a + b(x) \qquad (7)$$

In Equation 7, a equals the intercept of the line and b is the slope of the line. Using the cost-estimating relationship, we were able to calculate expected FY2014 spending levels for each PSC. Table 10 provides the intercept, slope, x variable, and calculated estimated spending for FY2014 for each of the PSCs. We used the estimated FY2014 spending to set a spending ceiling or floor as one of the constraints for the decision variables in the LP model.

Table 10.   Cost-Estimate Relation Results by PSC

PSC	Intercept	Slope	Variable	Estimated Cost
D302	25587812970	-12678733	2014	$52,844,979.43
D307	-54202597419	27000940	2014	$177,295,962.12
D310	-2084158677	1037397.7	2014	$5,160,351.36
D314	-12983736132	6470628.8	2014	$48,110,241.28
R408	83597838754	-41447595	2014	$122,382,655.96
R413	-1357683376	675359	2014	$2,489,649.67
R423	0	0	2014	$0.00
R425	1.90324E+11	-94289977	2014	$423,592,392.11
R497	-147116746.2	73180.275	2014	$268,327.68
R707	-4109821281	2044348.2	2014	$7,495,943.31

The second process we used to determine a spending floor or ceiling was to group each of the PSCs into three categories and assign a weighting factor of one, two, or three based on the perceived value that they provide to the warfighter. The PSCs that provide the highest values to the warfighter are assigned a value of one, and the PSCs with the lowest values are given a three. The PSCs that SPAWAR instructed us not to change are given a value of one, and the rest were evaluated based on spending history from FY2010 through FY2012. The PSCs that experienced a spending decrease of less than 15% were given a value of two. The PSCs that decreased their spending by greater than 15% were

assigned a value of three. We then assigned a maximum percentage for spending reduction for each of the weighting factors.

The PSCs assigned a weighting factor of one have no decrease in spending. PSCs with a weighting factor of two have a maximum reduction of 20%. PSCs with a weighting factor of three have a maximum reduction of 40%. We applied the weighting factor to SPAWAR's FY2012 spending level to calculate a spending floor or ceiling to be used as a constraint for each of the PSCs. Table 11 provides the results of these calculations.

Table 11.   Calculated FY2014 Spending

PSC	FY2012 Spending	Maximum Reduction Percentage	FY2014 Spending
D302	$82,253,784.36	0%	$82,253,784.36
D307	$113,109,109.62	0%	$113,109,109.62
D310	$2,509,549.82	0%	$2,509,549.82
D314	$32,206,286.64	20%	$25,765,029.31
R408	$190,362,881.78	40%	$114,217,729.07
R413	$1,350,718.00	20%	$1,080,574.40
R423	$0.00	40%	$0.00
R425	$540,445,175.13	40%	$324,267,105.08
R497	$146,360.55	20%	$117,088.44
R707	$4,088,696.35	20%	$3,270,957.08
Total	$966,472,562.25	20%	$666,590,927.18

We used the combination of the predicted FY2014 spending levels and the weighted maximum reduction in FY2012 spending to develop the spending ceilings and floors as constraints for each of the PSCs. Table 12 provides both the ceiling and floor for each of the PSCs.

Table 12. Spending Range by PSC

PSC	Spending Floor	Spending Ceiling
D302	$82,253,784.36	$82,253,784.36
D307	$113,109,109.62	$113,109,109.62
D310	$2,509,549.82	$2,509,549.82
D314	$27,375,343.64	$48,110,241.28
R408	$122,382,655.96	$123,735,873.16
R413	$1,148,110.30	$2,489,649.67
R423	$0.00	$0.00
R425	$351,289,363.83	$423,592,392.11
R497	$124,406.47	$268,327.68
R707	$3,475,391.90	$7,495,943.31

Now that the decision variables, objective function, and constraints have been identified, the mathematical LP model is written out.

B. SUMMARY OF THE LINEAR OPTIMIZATION MODEL

The mathematical model defines in writing what each of the decision variables are, what the objective function is, and what the constraints are.

1. Decision Variables:

D302, D307, D310, D314, R408, R413, R423, R425, R497, R707

2. Objective Function:

$Z \leq .0757(D302) + .0933(D307) + .0021(D310) + .0273(D314) + .2046(R408) + .0006(R413) + .0000(R423) + .5945\$1(R425) + .0001(R497) + .0018(R707)$

3. Subject to:

$(D302) + (D307) + (D310) + (D314) + (R408) + (R413) + (R423) + (R425) + (R497) + (R707) \leq \$698,276,426.36$

$D302 \geq \$82,253,784.36$

$D307 \geq \$113,109,109.62$

$D310 \geq \$2,509,549.82$

$D314 \geq \$32,913,270.80$

R408 ≥$123,735,873.16

R413 ≥ $2,489,649.67

R423 ≥ $0.00

R425 ≥ $351,289,363.83

R497 ≥ $124,406.47

R707 ≥ $3,475,391.90

D302 ≤ $82,253,784.36

D307 ≤ $113,109,109.62

D310 ≤ $2,509,549.82

D314 ≤ $32,913,270.80

R408 ≤ $123,735,873.16

R413 ≤ $2,489,649.67

R423 ≤ $0.00

R425 ≤ $351,289,363.83

R497 ≤ $124,406.47

R707 ≤ $3,475,391.90

D302 ≥ 0, D307 ≥ 0, D310 ≥ 0, D314 ≥ 0, R408 ≥ 0, R413 ≥ 0, R423 ≥ 0, R425 ≥ 0, R497 ≥ 0, R707 ≥ 0

To obtain the optimal solution of our LP model, we used Solver in Microsoft Excel. Table 13 shows the results of the LP model.

Table 13. Linear Programming Model Results in Excel

	D302	D307	D310	D314	R408	R413	R423	R425	R497	R707			
					PSCs								
Decision Variables	$82,253,784.36	$113,109,109.62	$2,509,549.82	$25,765,029.31	$114,217,729.07	$1,080,574.40	$0.00	$355,952,604.13	$117,088.44	$3,270,957.08			
Obj Function: Reduce PSC Spending	0.0757	0.0933	0.0021	0.0273	0.2046	0.0006	0.0000	0.5945	0.0001	0.0013	252,473,016.75		
Constraints											LHS	Sign	RHS
Total Spending must be less than	1	1	1	1	1	1	1	1	1	1	$698,276,426.23	=	$698,276,426.23
Spending Floor D302	1										$82,253,784.36	≥	$82,253,784.36
Spending Floor D307		1									$113,109,109.62	≥	$113,109,109.62
Spending Floor D310			1								$2,509,549.82	≥	$2,509,549.82
Spending Floor D314				1							$25,765,029.31	≥	$25,765,029.31
Spending Floor R408					1						$114,217,729.07	≥	$114,217,729.07
Spending Floor R413						1					$1,080,574.40	≥	$1,080,574.40
Spending Floor R423							1				$0.00	≥	$0.00
Spending Floor R425								1			$355,952,604.13	≥	$324,267,105.08
Spending Floor R497									1		$117,088.44	≥	$117,088.44
Spending Floor R707										1	$3,270,957.08	≥	$3,270,957.08
Spending Ceiling D302	1										$82,253,784.36	≤	$82,253,784.36
Spending Ceiling D307		1									$113,109,109.62	≤	$113,109,109.62
Spending Ceiling D310			1								$2,509,549.82	≤	$2,509,549.82
Spending Ceiling D314				1							$25,765,029.31	≤	$48,110,241.28
Spending Ceiling R408					1						$114,217,729.07	≤	$122,382,655.96
Spending Ceiling R413						1					$1,080,574.40	≤	$2,489,649.67
Spending Ceiling R423							1				$0.00	≤	$0.00
Spending Ceiling R425								1			$355,952,604.13	≤	$423,592,392.11
Spending Ceiling R497									1		$117,088.44	≤	$268,327.68
Spending Ceiling R707										1	$3,270,957.08	≤	$7,495,943.31

C. MODEL RESULTS

The results of the LP model provide SPAWAR with the following recommendation for SPAWAR's PSC spending for FY2014.

D302 = $82,253,784

D307 = $113,109,109

D310 = -$2,509,549

D314 = $25,765,029

R408 = $114,217,729

R413 = $1,080,574

R423 = $0

R425 = $355,952,604

R497 = $117,088

R707 = $3,270,957

The value of the objective function at the optimal solution is $252,473,016. This number is the maximum value that SPAWAR can provide to its end user while decreasing overall spending by the minimum of 15% with the constraints of each PSC. The following shows the percentage reduction in spending for each PSC to make up the required 15% overall reduction.

D302 = $82,253,784 represents 0%

D307 = $113,109,109 represents 0%

D310 = $2,509,549 represents 0%

D314 = $25,765,029 represents 20%

R408 = $114,217,729 represents 40%

R413 = $1,080,574 represents 20%

R423 = $0 represents 0%

R425 = $355,952,604 represents 34%

R497 = $117,088 represents 20%

R707 = $3,270,957 represents 20%

D. SENSITIVITY ANALYSIS

To find how robust these results were to changes in the inputted data and the assumptions made in the LP model, we conducted a sensitivity analysis.

In conducting a sensitivity analysis, we used the Excel Sensitivity Report and Excel Answer Report. Using the sensitivity report extracted from the LP model, there are two items on the report: the Variable Cells section and the Constraints section. In the Variable Cells section, there are seven particular columns associated with the sensitivity report. The Cell column refers to the cell number in Excel of the associated number value in the Final Value column. The Name column is the decision variable that the Cell column is referring to.

The reduced cost is the rate that is affected if we force the decision variable to be a value other than zero. The objective coefficient is the coefficient for the different variables in the model. Both the reduced cost and the objective coefficient are the same throughout the variables, with the reduced cost having a value of zero and the objective coefficient having a value of one.

The Allowable Increase column and Allowable Decrease column show that the value range of the objective coefficient can be changed without having to develop a different model. Any value that is outside the allowable increase or allowable decrease that we want to find the solution for would cause us to resolve the model. In all of our variable cells, the only values that we have in our model are infinity or zero. In Excel, infinity's symbol is 1E+30.

The sensitivity report for the LP model can be found in Appendix B. As we start asking hypothetical "what if" questions, we start to determine whether the optimal solution changes and how it affects the overall objective function. These two questions can be answered by asking hypothetical questions such as "Will the optimal solution change if the final value of Decision Variables D302 $82,253,784.60 increases?" and "How will the change affect the objective function?" The answer is that we must resolve the model to answer this question because of the allowable increase of zero, but if we were to change "increases" to "decreases" in the first question, then the value would be in the allowable

range and the optimal solution would stay the same. The second question would be that the value of the objective function would change and the new objective function would be calculated using this equation:

$$1 – (\text{Range from 1 to 0}) \times \$82{,}253{,}784.60 = X \text{ (where } X < \$82{,}253{,}784.60) \qquad (8)$$

In the Constraints section of the sensitivity report, we have the same three columns—Cell, Name, and Final Value—as the Variables section. The next column is Shadow Price, and that is the column that shows the rate of change in the value of the objective function per increase of one dollar in the right-hand side (RHS) of the constraint. Other characteristics of the shadow price are that it must remain constant and still be within the range of the allowable increase and allowable decrease. Shadow prices that have a value of zero are considered a nonbinding constraint, meaning that they have a slack associated with them. *Slack* is the range that a value can be increased or decreased without impacting the optimal solution. The model does have one constraint that has a shadow price other than zero, but for this constraint, the shadow price is not of interest.

The next three columns are Constraint of Right-Hand Side, Allowable Increase, and Allowable Decrease. We created the RHS and determined its value through our analysis of the data, as covered in the preceding chapter, but the Excel Solver determined the allowable increase and allowable decrease.

The answer report extracted from the Excel model has three different sections: Objective Cell, Variable Cells, and Constraints. The sensitivity analysis focuses on the Constraints section of the answer report. The information in the Constraint section is divided into six columns: Cell, Name, Cell Value, Formula, Status, and Slack.

The first three columns of the Constraint section are Cell, Name, and Cell Value. These columns are exactly the same columns in the sensitivity report. The next column is the Formula column, which gives an equation that defines the constraint. We inputted the equation in order to create the constraint. The next two columns—Status and Slack—are what the answer report generates. Both of these columns are the heart of the answer report.

The Status column gives the option of either binding or not binding. A simple definition of *binding* is zero slack; a more complex definition is that the given solution is the

optimal solution. *Not binding* means that there is a slack, or range of values, for that constraint to still meet the optimal solution.

The Slack column gives eight not-binding constraints out of the total 21 constraints. The eight constraints are a spending ceiling of PSCs D314, R408, R413, R425, R497, and R707 and a spending floor of PSC R425. The answer report for the model can be found in Appendix C, but in comparing the values to the sensitivity report, they are the same amounts as those in either the Allowable Decrease column or the Allowable Increase column. Another note is that even though the sensitivity report creates a shadow price of zero, the other considered constraints in the answer report are still considered binding. The reason is the other constraints given created the rest of the constraints to be binding.

The following chapter provides a summary of the results of the linear programming model and a budget recommendation for FY2014 spending on management services for SPAWAR.

THIS PAGE INTENTIONALLY LEFT BLANK

VII. CONCLUSION AND RECOMMENDATIONS

A.   SUMMARY

In this thesis, we developed a linear programming model to use as a capital budgeting tool in order to provide a budget recommendation to SPAWAR. The OMB is requiring a 15% reduction in SPAWAR's spending on management support services in the FY2014 budget. The primary focus of this thesis was to create a decision model that would provide analysis and recommendations on how to reduce spending within 10 PSCs. The analysis will allow SPAWAR to achieve their necessary budget requirements while minimizing the impact on command missions. We developed the decision model, analyzed the results, and in this chapter, provide recommendations to SPAWAR for PSC spending that can be effectively utilized for the FY2014 budget.

B.   DEVELOPING THE MODEL

The raw data from the FPDS had first to be analyzed prior to developing the linear programming model. Identifying the essential information in the 18,600 line items of data from FY2010 to FY2012 was the next step. We grouped the data by fiscal year and PSC. We then established the estimated FY2014 spending limit from the FY2012 actual spending with the formula FY\$2014 = FY\$2012 x .85 x .85 to create a 15% reduction for FY2013 and another 15% reduction for FY2014; this became our first constraint.

Our constraints came from identifying potential spending limits for each PSC by establishing spending floors and ceilings. We used two methods for establishing these constraints. The first method was a simple linear regression based on spending levels from FY2010 to FY2012 and using the formula $Y = a + b(x)$. The second method was to group the PSCs into a priority level of one, two, or three. PSCs with a priority level of one were not reduced from FY2012 levels, PSCs with a priority level of two could be reduced a maximum of 15%, and PSCs with a priority level of three could be reduced a maximum of 40%. To determine the spending floor for each PSC, we used the lower of these two methods. To set the spending ceiling for each PSC, we used the higher of these two methods.

Once we established the FY2014 estimated spending limit and determined the spending floors and ceilings, the next step was to establish the objective function. The objective function is merely to maximize the value of SPAWAR spending for each PSC

based on all constraints. We determined the maximized value by dividing the weighted average of each PSC by the total weighted spending of all PSCs. We then programmed the constraints into the linear programming model.

We developed the linear programming model to be used as a decision model for SPAWAR. The model provides recommended reductions in spending based on the objection function, the decision variables, and the constraints of those variables entered for each PSC. The values of the constraints can adjust for each PSC, and the overall budget level can also adjust for other spending limits. The results of this model return values that are in line with estimated future spending limits and will achieve the 15% reduction goal for SPAWAR with minimal impact to the warfighter.

C.   RECOMMENDATION TO SPAWAR

In accordance with the linear programming model results and analysis presented in this project, we recommend that SPAWAR reduce spending to the following limits to match estimated FY2014 budget levels.

The model reports that there is slack in several of the PSCs, which allows for adjustments to the numbers in Table 14. The amount of allowable increase or decrease of spending is presented in Table 15. An adjustment to one or more of these PSCs must be met with an equal but opposite adjustment to one or more PSCs to maintain the FY2014 spending estimate of $698,276,426.

Table 14.   FY2014 Spending Recommendation by PSC

D302	D307	D310	D314	R408	R413	R423	R425	R497	R707
$82,253,784.36	$113,109,109.62	$2,509,549.82	$25,765,029.31	$114,217,729.07	$1,080,574.40	$0.00	$355,952,604.13	$117,088.44	$3,270,957.08

Table 15.   Available Increase and Decrease of Spending by PSC From Recommended Spending Levels

PSC	Available Increase	Available Decrease
D302	$ -	$ -
D307	$ -	$ -
D310	$ -	$ -
D314	$ 22,345,211.97	$ -
R408	$ 8,164,926.89	$ -
R413	$ 1,409,075.27	$ -
R423	$ -	$ -
R425	$ 67,639,787.99	$ 31,685,499.05
R497	$ 151,239.24	$ -
R707	$ 4,224,986.23	$ -

D.   FURTHER RESEARCH

Further research is suggested to gain the most benefit from this model and for the model to be used as a planning tool. We determined the spending floors and ceilings based on our interpretation of what was most important to SPAWAR in order to impact the warfighter the least. Other considerations are listed as follows:
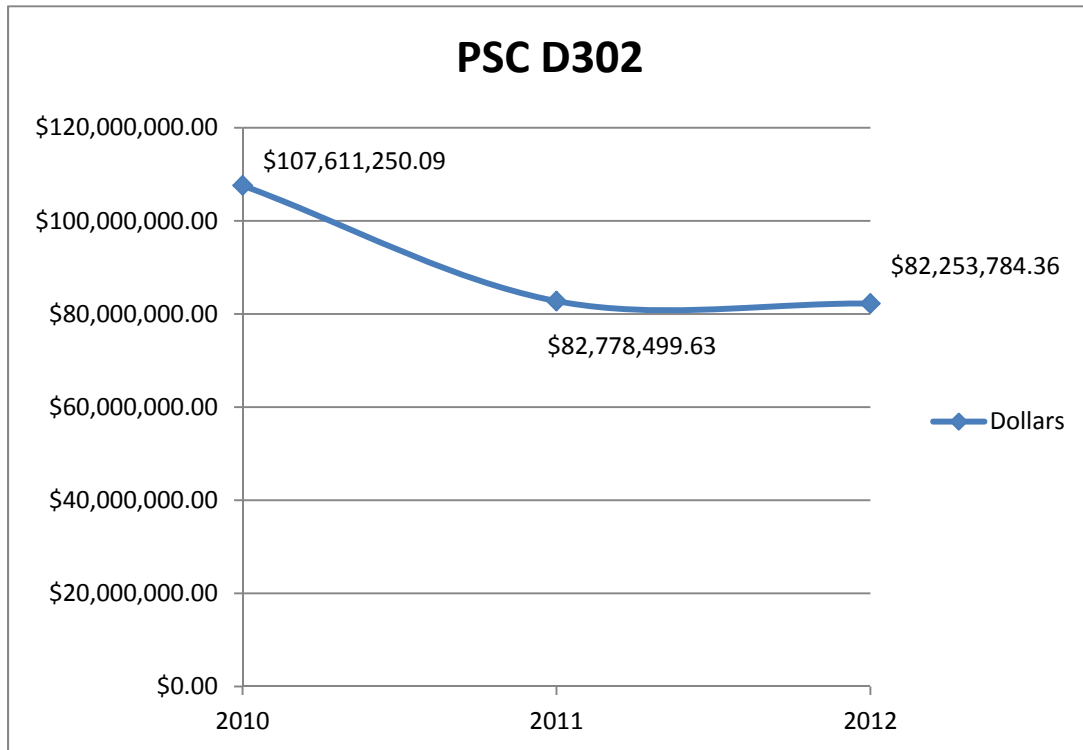
- Can PSCs be further combined to eliminate redundancy?
- What is the best method for determining the spending floor and ceiling for each PSC?
- Can the constraints be better developed?
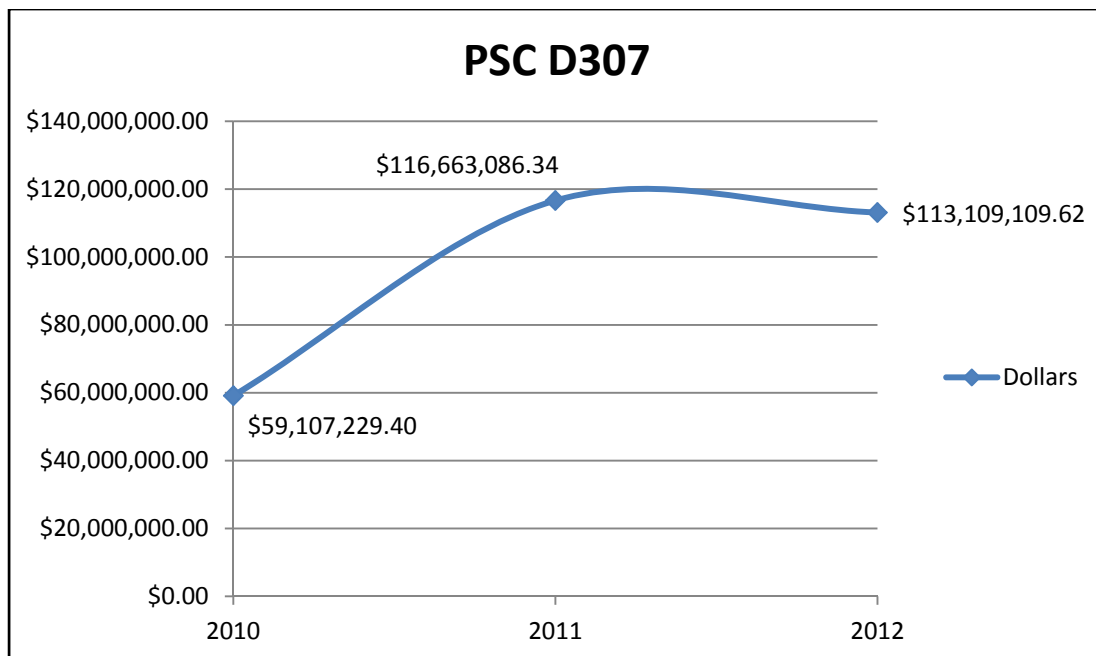- Are all current contracts written for the correct PSC?

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX A. SCATTER PLOT OF PRODUCT SERVICE CODES
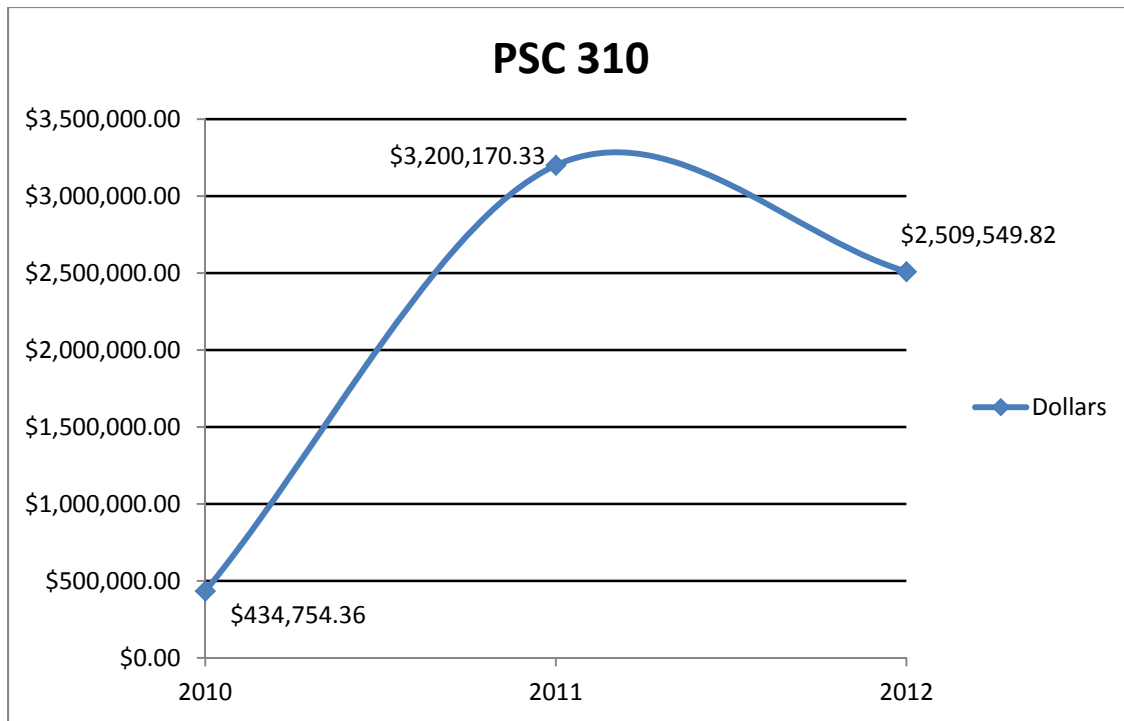

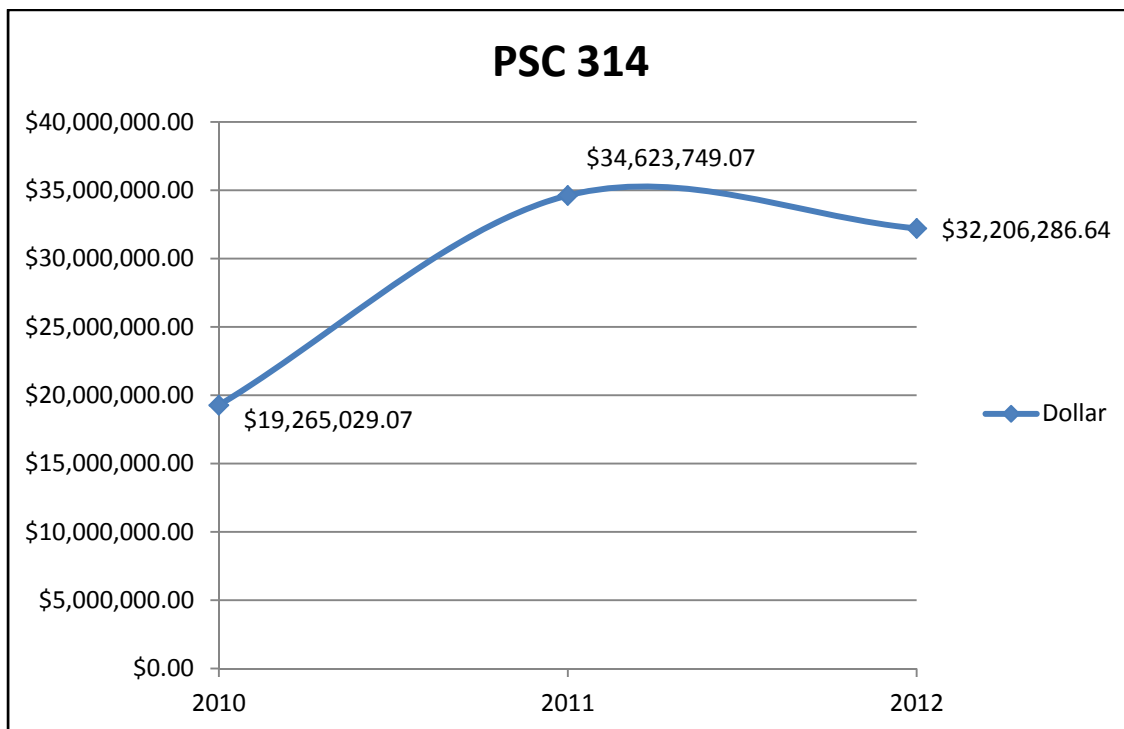**Figure 9.   Scatter Plot of Spending on PSC D302 From FY2010 Through FY2012**

Figure 10.   Scatter Plot of Spending on PSC D307 From FY2010 Through FY2012
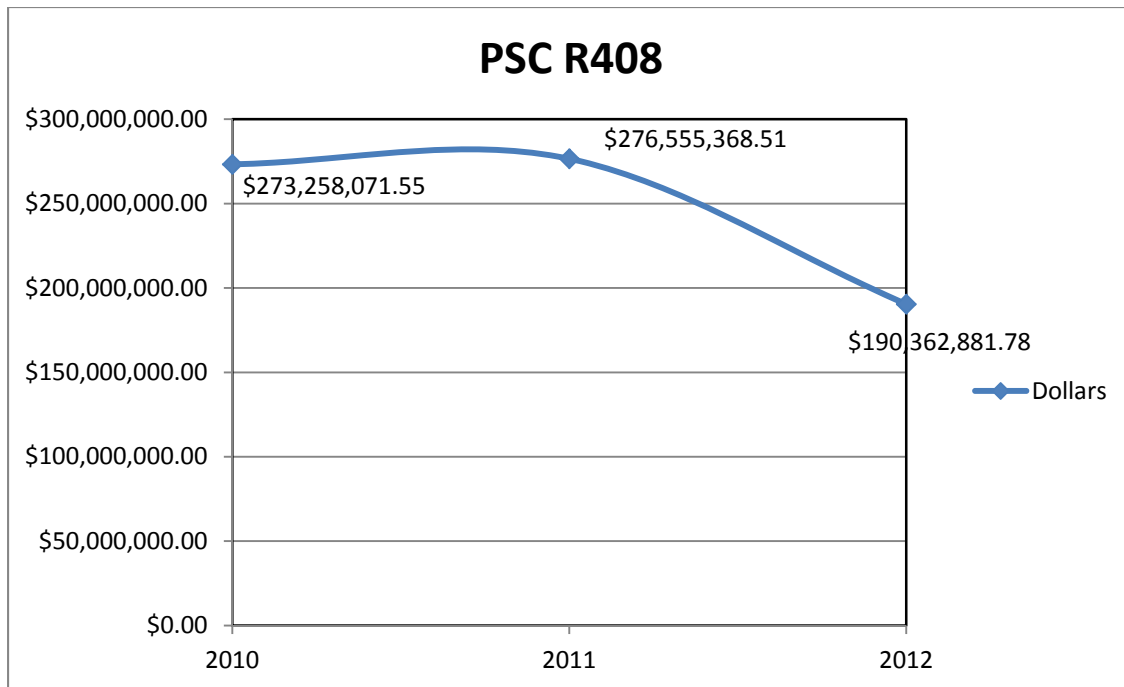
Figure 11. Scatter Plot of Spending on PSC D310 From FY2010 Through FY2012

Figure 12. Scatter Plot of Spending on PSC D314 From FY2010 Through FY2012

Figure 13. Scatter Plot of Spending on PSC R408 From FY2010 Through FY2012

Figure 14. Scatter Plot of Spending on PSC R413 From FY2010 Through FY2012
Note. R423 has zero dollars spent in FY2010 through FY2014,
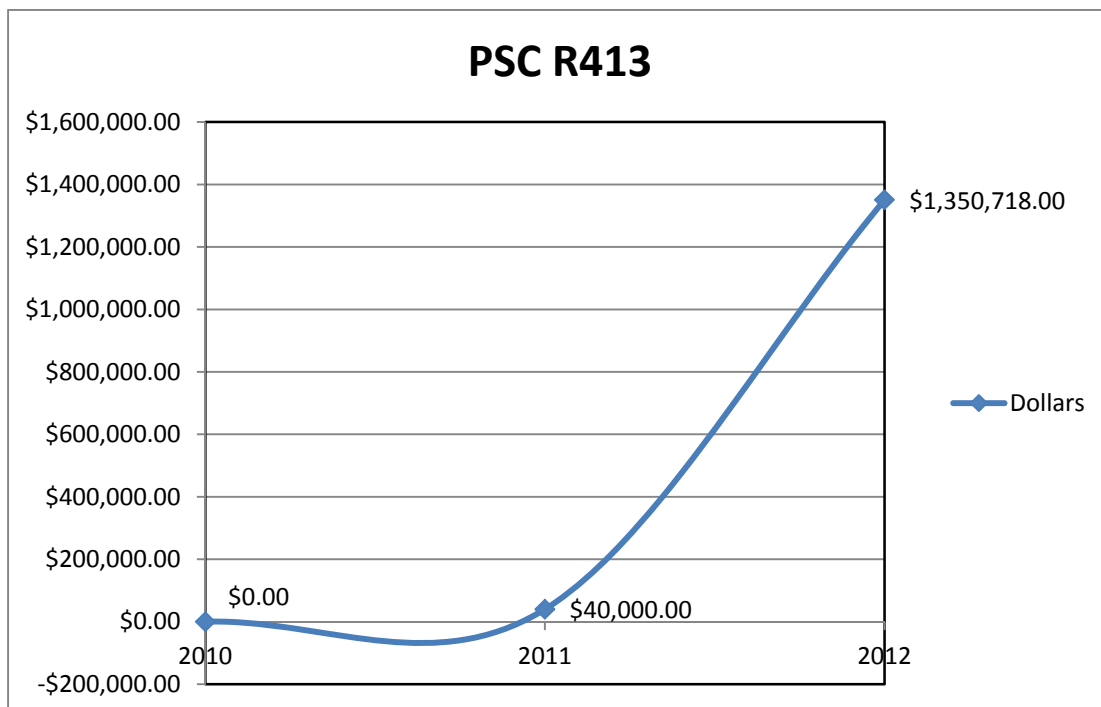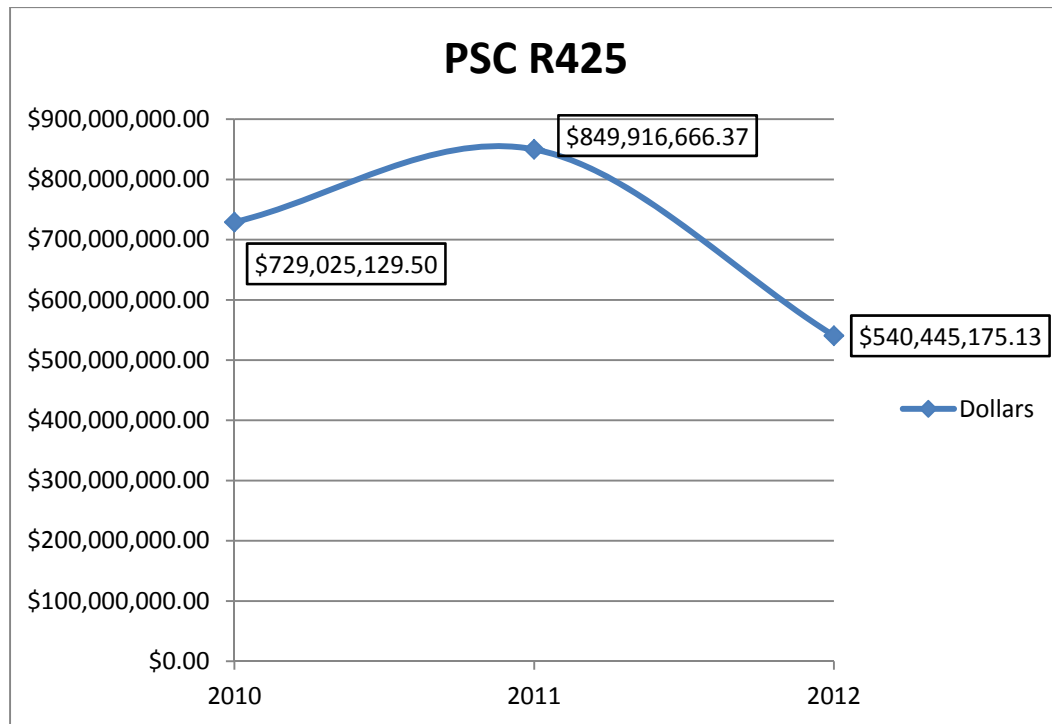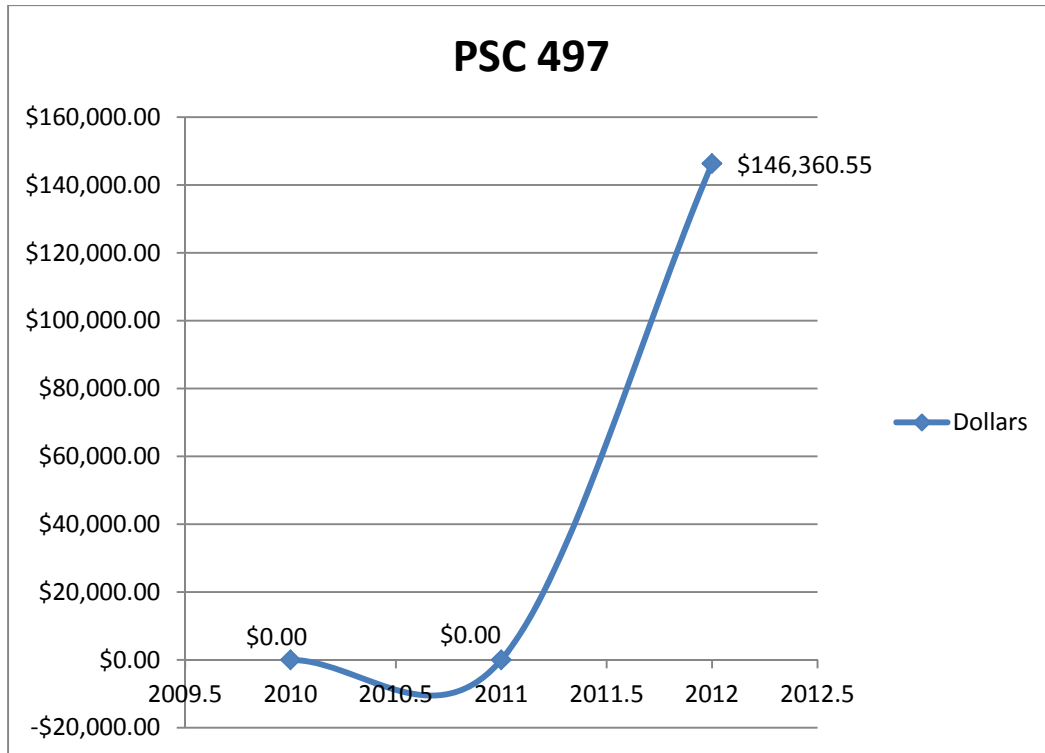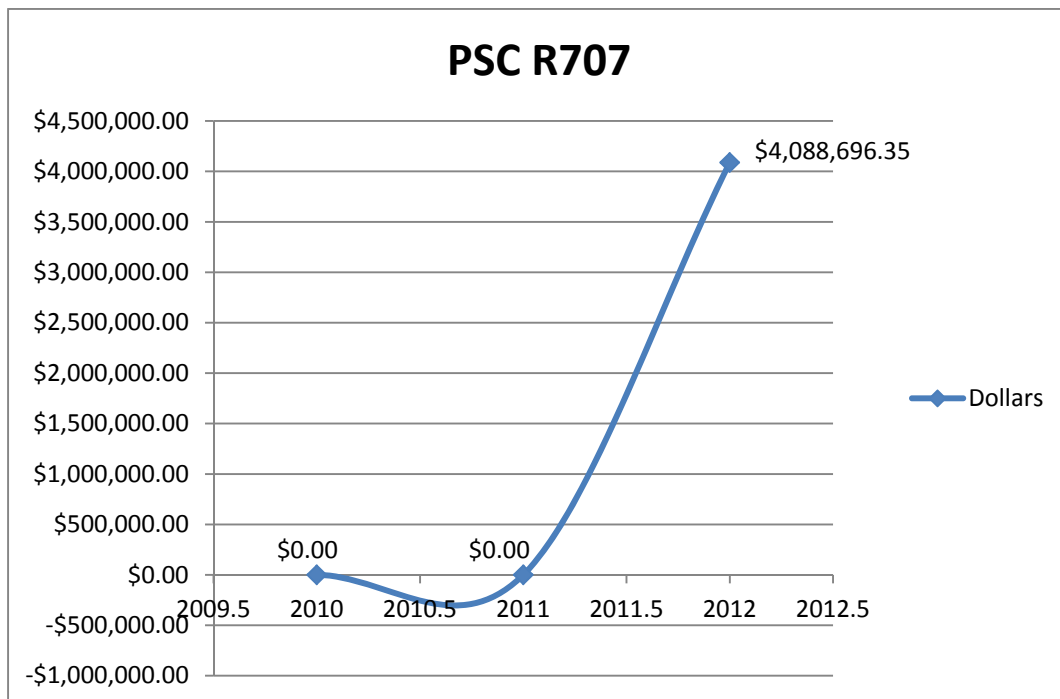so there is no data to plot.

Figure 15.   Scatter Plot of Spending on PSC R425 From FY2010 Through FY2012

Figure 16. Scatter Plot of Spending on PSC R497 From FY2010 Through FY2012

Figure 17. Scatter Plot of Spending on PSC R707 From FY2010 Through FY2012

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX B. SENSITIVITY REPORT

Adjustable Cells

Cell	Name	Final Value	Reduced Gradient
$C$3	Decision Variables D302	$82,253,784.36	$0.00
$D$3	Decision Variables D307	$113,109,109.62	$0.00
$E$3	Decision Variables D310	$2,509,549.82	$0.00
$F$3	Decision Variables D314	$25,765,029.31	$0.00
$G$3	Decision Variables R408	$114,217,729.07	$0.00
$H$3	Decision Variables R413	$1,080,574.40	$0.00
$I$3	Decision Variables R423	$0.00	$0.00
$J$3	Decision Variables R425	$355,952,604.13	$0.00
$K$3	Decision Variables R497	$117,088.44	$0.00
$L$3	Decision Variables R707	$3,270,957.08	$0.00

Constraints

Cell	Name	Final Value	Lagrange Multiplier
$M$19	Spending Ceiling D302 LHS	$82,253,784.36	$0.00
$M$20	Spending Ceiling D307 LHS	$113,109,109.62	$0.00
$M$21	Spending Ceiling D310 LHS	$2,509,549.82	$0.59
$M$22	Spending Ceiling D314 LHS	$25,765,029.31	$0.00
$M$23	Spending Ceiling R408 LHS	$114,217,729.07	$0.00
$M$24	Spending Ceiling R413 LHS	$1,080,574.40	$0.00
$M$25	Spending Ceiling R423 LHS	$0.00	$0.00
$M$26	Spending Ceiling R425 LHS	$355,952,604.13	$0.00
$M$27	Spending Ceiling R497 LHS	$117,088.44	$0.00
$M$28	Spending Ceiling R707 LHS	$3,270,957.08	$0.00
$M$8	Total Spending must be less than LHS	$698,276,426.23	$0.59
$M$9	Spending Floor D302 LHS	$82,253,784.36	-$0.52
$M$10	Spending Floor D307 LHS	$113,109,109.62	-$0.50
$M$11	Spending Floor D310 LHS	$2,509,549.82	-$0.59
$M$12	Spending Floor D314 LHS	$25,765,029.31	-$0.57
$M$13	Spending Floor R408 LHS	$114,217,729.07	-$0.39
$M$14	Spending Floor R413 LHS	$1,080,574.40	-$0.59
$M$15	Spending Floor R423 LHS	$0.00	-$1.42
$M$16	Spending Floor R425 LHS	$355,952,604.13	$0.00
$M$17	Spending Floor R497 LHS	$117,088.44	-$0.59
$M$18	Spending Floor R707 LHS	$3,270,957.08	-$0.59

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX C. ANSWER REPORT

Target Cell (Max)

Cell	Name	Original Value	Final Value
$M$5	Obj Function:Reduce PSC Spending	252,473,016.75	252,473,016.75

Adjustable Cells

Cell	Name	Original Value	Final Value
$C$3	Decision Variables D302	$82,253,784.36	$82,253,784.36
$D$3	Decision Variables D307	$113,109,109.62	$113,109,109.62
$E$3	Decision Variables D310	$2,509,549.82	$2,509,549.82
$F$3	Decision Variables D314	$25,765,029.31	$25,765,029.31
$G$3	Decision Variables R408	$114,217,729.07	$114,217,729.07
$H$3	Decision Variables R413	$1,080,574.40	$1,080,574.40
$I$3	Decision Variables R423	$0.00	$0.00
$J$3	Decision Variables R425	$355,952,604.13	$355,952,604.13
$K$3	Decision Variables R497	$117,088.44	$117,088.44
$L$3	Decision Variables R707	$3,270,957.08	$3,270,957.08

Constraints

Cell	Name	Cell Value	Formula	Status	Slack
$M$19	Spending Ceiling D302 LHS	$82,253,784.36	$M$19<=$O$19	Binding	0
$M$20	Spending Ceiling D307 LHS	$113,109,109.62	$M$20<=$O$20	Binding	0
$M$21	Spending Ceiling D310 LHS	$2,509,549.82	$M$21<=$O$21	Binding	0
$M$22	Spending Ceiling D314 LHS	$25,765,029.31	$M$22<=$O$22	Not Binding	22345211.97
$M$23	Spending Ceiling R408 LHS	$114,217,729.07	$M$23<=$O$23	Not Binding	8164926.89
$M$24	Spending Ceiling R413 LHS	$1,080,574.40	$M$24<=$O$24	Not Binding	1409075.267
$M$25	Spending Ceiling R423 LHS	$0.00	$M$25<=$O$25	Binding	0
$M$26	Spending Ceiling R425 LHS	$355,952,604.13	$M$26<=$O$26	Not Binding	67639787.99
$M$27	Spending Ceiling R497 LHS	$117,088.44	$M$27<=$O$27	Not Binding	151239.235
$M$28	Spending Ceiling R707 LHS	$3,270,957.08	$M$28<=$O$28	Not Binding	4224986.228
$M$8	Total Spending must be less than LHS	$698,276,426.23	$M$8=$O$8	Not Binding	0
$M$9	Spending Floor D302 LHS	$82,253,784.36	$M$9>=$O$9	Binding	$0.00
$M$10	Spending Floor D307 LHS	$113,109,109.62	$M$10>=$O$10	Binding	$0.00
$M$11	Spending Floor D310 LHS	$2,509,549.82	$M$11>=$O$11	Binding	$0.00
$M$12	Spending Floor D314 LHS	$25,765,029.31	$M$12>=$O$12	Binding	$0.00
$M$13	Spending Floor R408 LHS	$114,217,729.07	$M$13>=$O$13	Binding	$0.00
$M$14	Spending Floor R413 LHS	$1,080,574.40	$M$14>=$O$14	Binding	$0.00
$M$15	Spending Floor R423 LHS	$0.00	$M$15>=$O$15	Binding	$0.00
$M$16	Spending Floor R425 LHS	$355,952,604.13	$M$16>=$O$16	Not Binding	$31,685,499.05
$M$17	Spending Floor R497 LHS	$117,088.44	$M$17>=$O$17	Binding	$0.00
$M$18	Spending Floor R707 LHS	$3,270,957.08	$M$18>=$O$18	Binding	$0.00

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF REFERENCES

Assad, S. D. (2010, November 23). *Taxonomy for the acquisition of services*. Washington, DC: Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics.

Assad, S. D. (2012, August 27). *Taxonomy for the acquisition of services and supplies & equipment*. Washington, DC: Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics.

Balakrishnan, N., Render, B., & Stair, R., Jr. (2013). *Managerial decision modeling*. Boston, MA: Pearson Education.

Bather, J. (2000). *Decision theory*. West Sussex, England: John Wiley & Sons.

Berk, K., & Carey, P. (2000). *Data analysis with Microsoft Excel*. Pacific Grove, CA: Duxbury Thomson Learning.

Brady, P. (2011, December 6). *SPAWAR: Making the Navy's information dominance a reality*. Retrieved from http://www.public.navy.mil/spawar/Press/Documents/Publications/1.18.12_AFCEA_Kit_II.pdf

Brown, G. G. (2004). *Optimization-based military capital planning* (Master's thesis, Naval Postgraduate School). Retrieved from http://edocs.nps.edu/npspubs/scholarly/TR/2004/NPS-OR-04–002.pdf

Defense Procurement and Acquisition Policy (DPAP) Defense Pricing. (2012, October 10). *Taxonomy and spend analysis*. Retrieved from http://www.acq.osd.mil/dpap/ss/taxonomy.html

Donahue, S. F. (1992). *An optimization model for Army planning and programming* (Master's thesis, Naval Postgraduate School). Retrieved from http://edocs.nps.edu/npspubs/scholarly/theses/1992/Sep/92Sep_Donahue.pdf

Field, R. J. (1999). *Planning capital investments in Navy Forces* (Master's thesis, Naval Postgraduate School). Retrieved from http://hdl.handle.net/10945/8824

General Services Administration (GSA) Office of Government-wide Policy. (2011, August). *Federal Procurement Data System product and service codes manual*. Retrieved from Acquisition Central website: http://www.acquisition.gov/PSC%20Manual%20-%20Final%20-%2011%20August%202011.pdf

Kutz, G., & Solis, W. (2003, July). *Navy Working Capital Fund: Backlog of funded work at the Space and Naval Warfare Systems Command was consistently understated* (GAO-03–668). Washington, DC: Government Accountability Office.

Newman, A. M., Brown, G. G., Dell, R. F., Giddings, A., & Rosenthal, R. E. (2000). *An integer-linear program to plan procurement and deployment of Space and Missile Assets Forces* (Master's thesis, Naval Postgraduate School). Retrieved from http://edocs.nps.edu/npspubs/scholarly/TR/2000/NPS-OR-00–005.pdf

Pike, J. (2011, May 7). Space and Naval Warfare Systems Command (SPAWAR). Retrieved from http://www.globalsecurity.org/military/agency/navy/spawar.htm

Ragsdale, C. (2007). *Spreadsheet modeling & decision analysis* (5th ed.). Mason, OH: Thomson Higher Education.

Space and Naval Warfare Systems Command (SPAWAR). (2005, December 02). SSC San Diego Center overview. Retrieved from http://www.spawar.navy.mil/sandiego/center_overview/html/introduction.html

Space and Naval Warfare Systems Command (SPAWAR). (2012). *Space and Naval Warfare Systems Command (SPAWAR) strategic plan (2012–2016)* [PDF brochure]. Washington, DC: Author.